Hazardous Waste Management In Massachusetts

Silverware POWER TOOLS communications HOUSEHOLD APPLIANCES

Lubricating Oil & Grease AIRCRAFT ENGINES PLASTICS ELECTRONICS Jewelry Leather Products

Construction Telephones Schools Pharmaceuticals CLOTHING Hospitals Printing

otographic INSTRUMENTS Paints & Varnishes

uipment TEXTILES COMPUTERS FARM MACHINERY Plastic INDUSTRIAL INSTRUMENTS

RESEARCH LABS Fertilizers Containers

ROPLATING BOOKS

A Draft Environmental Impact Report

Prepared by:

The Department of Environmental Management
Executive Office of Environmental Affairs
John Bewick, Secretary

Hazardous Waste Management in Massachusetts

Draft Environmental Impact Report

Prepared by:

The Massachusetts Department of Environmental Management
Bureau of Solid Waste Disposal

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This draft report was prepared jointly by the Massachusetts Bureau of Solid Waste Disposal and Clark-McGlennon Associates, Inc., Roy F. Weston Associates, Inc., and Edward I. Selig, Esq. All errors and omissions are the responsibility of the Bureau and not of the contractors.

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Executive Summary

As much as 300,000 tons of waste materials generated in Massachusetts each year are classified as hazardous wastes. These wastes have been classified as hazardous because they pose risks of fire, explosion, or corrosion if improperly handled or because they are toxic. At present, about half of these wastes are solvents and lubricating oils from cars, trucks and industrial machines. Also, sludges from municipal and industrial water treatment plants make up increasingly large share of hazardous waste generation in Massachusetts. Waste types are introduced briefly in Chapter 2 ("Technology") and estimated amounts of waste generated are presented in Chapter 5 ("Current Situation").

In the past, these hazardous wastes were often handled and disposed of improperly. However, federal and state laws now place strict controls on hazardous waste disposal to protect public health and the environment. Specifically, the Resource Conservation and Recovery Act (RCRA) and the EPA regulations implementing RCRA establish:

- a <u>manifest system</u> for tracking all hazardous wastes from "cradle to grave,"

- <u>standards</u> for handling and disposal of wastes by generators, transporters and operators of all waste management facilities

- a <u>permit system</u> for review and approval of all treatment, storage and disposal facilities.

These federal laws and regulations are supplemented by two state laws:

- the Massachusetts Hazardous Waste Management Act

- the Massachusetts Hazardous Waste Facilities Siting Act,

as well as other existing federal and state environmental laws (such as the federal Clean Air Act and the Massachusetts Wetlands Protection Act). These legal controls over hazardous waste management are presented in Chapter 3 ("Legal Framework").

Not only is a legal framework established for the management of hazardous waste -- the technology is also available to properly treat and dispose of these materials.

The most desirable way to handle

hazardous waste is to reduce its generation at the source. In fact, it has been estimated that waste generation can be cut in half through changes in materials and manufacturing processes. The added costs associated with these changes can be paid back through reduced disposal costs and reduced risks of generator liability for mistakes by waste service firms. In addition, generators can further reduce the wastes they have to send to off-site waste management facilities by recycling wastes at the plant, by treating or processing wastes themselves, or by exchanging wastes with other firms that can make use of them as input materials.

Technology is also available to manage those wastes which remain after waste reduction by generators. For example, contaminated oils and solvents can be filtered and distilled for reuse or burned as a fuel. Sludges can be de-watered, processed into a solid that is much less hazardous, and sealed in landfills. Acids can be neutralized. Heavy metals can be precipitated and recycled. By Massachusetts law, secure landfills can only be used for those wastes where such treatment, recovery or destruction technologies are not feasible. Nevertheless, secure landfills can be designed and operated to isolate wastes from the environment, through the use of leachate monitoring and withdrawal systems, liners, covers and other protective measures. These technologies are described at greater length in Chapter 2.

The impacts of properly designed waste management facilities on public health and the environment are modest -- much, much less than the impacts of not having adequate treatment facilities to properly handle Massachusetts wastes. For example, air pollutants from incinerators and water emissions from aqueous treatment facilities are minimized by scrubbers and other pollution control equipment, which is in turn backed up by automatic emission monitoring and process shutdown systems. In another example, potential impacts on groundwater from accidentally spilled wastes are prevented by special spill prevention procedures, which are backed up by dikes, liners and other containment and cleanup measures. These and other measures to avoid impacts are discussed in Chapter 2 ("Technology") and Chapter 4 ("Protective Mechanisms").

The potential impacts of illegal dumping are, in contrast, extremely serious, including the poisoning of underground water supplies and the release of toxic vapors into the air. It should be evident to everyone that illegal, uncontrolled disposal of hazardous wastes is not an option but rather a serious crime. There is nevertheless a "no-action alternative" for the Commonwealth as a whole, namely not to have any new facilities built for sound

waste management. This would continue an unacceptable dependence on distant facilities which are quickly reaching capacity. A shortfall of treatment and disposal capacity in Massachusetts exists for several types of waste. This is discussed in Chapter 5 ("Current Situation"). The potential effects of a continued shortfall are discussed in Chapter 1 ("Introduction"), including sudden plant shutdowns and layoffs and pressures on unscrupulous people to illegally pollute our land and water, when out-of-state facilities become unavailable. Furthermore, as generators anticipate such effects, many may decide to relocate (or divert new growth) to areas with adequate treatment facilities, permanently disrupting the state's economy. New, safe hazardous waste management facilities are thus urgently needed to protect the economic and environmental health of Massachusetts.

While knowledgeable people recognize this pressing statewide need for new treatment capacity, representatives of most communities are nevertheless afraid of the localized risks or impacts of potential facilities. The Massachusetts Siting Law, however, provides a process through which communities can negotiate a legally enforceable Siting Agreement with potential developers. The Siting Agreement stipulates protective measures that can be taken to reduce potential impacts to acceptable levels and specifies compensation for the community to offset any remaining impacts. For example, representatives of the community and the developer might arrange for an independent specialist to be hired by the host municipality with funds provided by the facility operator, to monitor facility operations and performance data on a periodic basis. Other examples of protective mechanisms and benefits which negotiators might identify are provided in Chapter 4 ("Protective Mechanisms").

It is clear that wise and thoughtful action is required. We hope that this report will serve to inform and bring together community officials, facility developers and citizens to solve the Commonwealth's pressing need for modern, safe hazardous waste management facilities.

Background

In response to increasing public concern about the generation, management and disposal of hazardous wastes in Massachusetts, the General Court approved Chapter 21D of the General Laws. The new Act establishes a Hazardous Facilities Site Safety Council and requires the Department of Environmental Management to prepare a Statewide Environmental Impact Report.

Under the Act and for the purposes of this document, hazardous wastes are defined as industrial solid or liquid toxic waste including petroleum oils and other petroleum products. This definition does not include nuclear or radioactive wastes.

This document is designed to provide a readable working handbook for persons interested in or concerned about siting hazardous waste facilities in Massachusetts. Readers are expected to include the general public, community leaders, developers of waste disposal facilities, public interest groups, state and federal agency personnel and members of the legislature.

This report has been prepared by the Bureau of Solid Waste Disposal. The intent of this report is to provide information on the alternative methods and probable impacts of managing and disposing of hazardous wastes. It is important for the public to understand that hazardous waste can be properly disposed of without harm to public health or to the environment. The hazardous waste situation in Massachusetts is manageable. It will be possible to safely treat and dispose of the wastes produced by our industries through the reduction of the volume of wastes being produced and through the construction of several modern treatment facilities. At present, service companies exist that have adequate capacity to handle all demand for waste disposal through out-of-state facilities. While such facilities are increasingly becoming unavailable to Massachusetts users, this diposal service gives us a grace period to solve the problem in the Commonwealth.

In preparing this report, the Bureau of Solid Waste Disposal has attempted to meet the needs of individuals, organizations and communities who are likely to be involved in siting a hazardous waste management

facility. It is not possible to provide the level of detail that will be necessary in specific siting situations. However, we have attempted, through the bibliography, to provide the reader with a guide to the location of additional information. A chart in the appendix provides a list of agencies and their specific responsibilities for additional points of contact.

This document will be updated annually. It is expected that the quality of the data on amounts and types of wastes being generated and the capacity of waste management facilities will improve. It should be possible to draw on actual siting examples in future reports. The Bureau also hopes to provide more information on hazardous waste management in the other New England states as well as Europe and Asia.

Based on the comments received, this report will be revised where appropriate and issued in final form in April 1981. At that time copies will be distributed to all interested parties and will be available through the Bureau of Solid Waste Disposal.

Chapter 1: Introduction

Summary

The Hazardous Waste Facility Siting Act grants primary authority for siting hazardous waste facilities to the local community. It creates a siting procedure in which a facility developer and officials of the local community negotiate enforceable stipulations for facility construction and operation. The siting agreement may also provide compensation and incentives to the host community to offset costs associated with the facility.

To encourage developers to build safe and secure facilities in Massachusetts, we need strict regulation and enforcement. We also need citizen recognition that there is far more to gain (in health protection, in a secure state economy) than to lose from agreeing to site new hazardous waste management facilities.

This report presents the need for additional hazardous waste management facilities in the Commonwealth, describes the siting process and provides the reader with fundamental information on management options. It can be used by developers, community officials and concerned citizens.

I. Legislative History

In 1976 the United States Congress enacted the Resource Conservation and Recovery Act (RCRA) in response to increasing evidence of unsafe management and storage of all hazardous wastes throughout the United States. The Act (which concerns hazardous wastes <u>other than</u> nuclear or radioactive:

- sets up a procedure for defining hazardous waste

- requires industries that operate hazardous waste management facilities to register their activities with the Environmental Protection Agency (EPA), or with an authorized state agency

- provides for a manifest system designed to track hazardous wastes from the point of generation to the point of disposal

- requires hazardous waste management facilities to be maintained and operated to minimize any threat to human health or to the environment

- provides for strict enforcement and severe penalties including imprisonment and fines up to $25,000 a day for violators.

With the passage of the Federal Act, it was evident that there would soon be large quantities of hazardous wastes that would have to be properly disposed of or safely stored. A survey by EPA indicated that there were several areas of the country that did not have adequate handling facilities to treat the wastes being generated locally. One of these areas was New England.

The Massachusetts Legislature responded to this situation in 1979 by creating a Special Commission on Hazardous Waste. The Commission was authorized to:

- investigate alternative procedures, criteria and guidelines for granting local and state approval of sites for new hazardous waste management facilities

- investigate prohibitions for siting hazardous waste facilities to protect ground water supplies

- investigate policies for creating a positive economic climate in Massachusetts for the siting of hazardous waste management facilities.

The Commission met regularly until June of 1980 when its report was delivered to the Massachusetts Legislature. The Commission's study indicated that the major deterrent to facility siting has been public opposition resulting from 1) misperceptions; 2) a lack of factual information; or 3) the feeling that a community has nothing to gain by hosting a facility. The Commission proposed the adoption of a Hazardous Waste Facility Siting Act designed to constructively resolve opposition with an open process that brings prospective developers and communities together early in the siting procedure in order to (i) reduce real and perceived risks and (ii) ensure that communities benefit from the siting project.

In July, 1980, the Massachusetts Legislature passed the Hazardous Waste Facility Siting Act which became Chapter 21D of the General Laws of the Commonwealth. In the new law, the primary authority for siting hazardous waste facilities is vested in the local community. The Department of Environmental Management (DEM) is largely responsible for carrying out State actions required to implement the new siting procedures. The Department of Environmental Quality Engineering (DEQE) continues in its role as

the regulatory authority with respect to the handling, management, treatment and disposal of hazardous waste. The Massachusetts Environmental Protection Act Office (MEPA) has the responsibility for the review of the environmental impacts of facilities designed to treat or store hazardous waste. All three of these agencies come under the Executive Office of Environmental Affairs (EOEA) and are charged with the responsibility to provide assurance of public health and safety, environmental safeguards and an informed decision-making process. A new body, the Site Safety Council, is created to act as an impartial arbiter of the siting process.

In brief, the new Siting Act:

- establishes a Hazardous Waste Facility Site Safety Council
- creates a procedure for siting new facilities through negotiations carried out between the developer and officials of the local community where the facility is to be located
- provides for the creation of Local Assessment Committees for the evaluation of siting proposals within a host community
- provides for technical assistance grants to Local Assessment Committees
- requires that an annual statewide environmental impact report be prepared (which is the basis for this report)
- mandates that a broad public information program on hazardous waste management practices be carried out and that extensive information be provided to parties directly involved in siting hazardous waste facilities.

The members of the Hazardous Waste Facility Site Safety Council are appointed by the Governor. When the Council meets to discuss a specific siting proposal, the Local Assessment Committee will appoint two residents of the host community to serve on the Council. Members of the Council include:

- The Secretary of Environmental Affairs
- The Secretary of Public Safety
- The Secretary of Communities and Development
- The Secretary of Economic Affairs
- The Commissioner of Environmental Quality Engineering
- The Commissioner of Environmental Management

- The Commissioner of Public Utilities

- Dr. Norton H. Nickerson (Chairman and public member at large)

- Joan N. Gardner (Massachusetts Municipal Association)

- John F. Malone (Massachusetts Health Officers Association)

- Henry W. Nowick (Associated Industries of Massachusetts)

- David G. Spackman (Local Boards of Health)

- David P. Swanson (Chemical Engineer)

- John Wilson, III (Hydrogeologist)

- Laurence Bacow (Environmental Affairs)

- James Rogers (Public member at large)

- Leo J. Santucci (Public member at large)

- Edward J. Calabreze (Public member at large)

- Deanna Ruffer (Public member at large)

- Joseph W. Walsh, Jr. (Public member at large)

II. The Siting Process

The responsibility for overseeing the siting process is divided between the local community, the Department of Environmental Management (DEM) and the Hazardous Waste Facilities Site Safety Council (the Council). The local communities have the major responsibility and authority in the siting process, and are required to make all decisions regarding site assignment and safety requirements for the facility. Representatives of the community negotiate an enforceable siting agreement with the facility developer that includes the agreed upon stipulations for the construction and operation of the facility. No state agency has the authority to override local decisions, except that there are provisions for arbitration of an impasse in negotiations between communities and the developer and for the courts to strike down capricious refusal of a site.

The Department of Environmental Management initiates many of the implementation actions and develops the regulations governing the process. The Council acts as the impartial overseer and arbiter of the siting process, assuring equity to communities, facility developers and to the general public, making certain key appointments

and providing assistance to communities.

The major elements of the new siting process are as follows:

- A developer submits a Notice of Intent (NOI) to the Site Safety Council, the Department of Environmental Management, and the Department of Environmental Quality Engineering, the host and abutting communitites, the regional planning agency, and the site owner. The NOI describes the proposed facility, the wastes to be processed, the siting process, the types of assistance available to communitites, compensation, and other benefits which might be negotiated with the host community. Filing the NOI starts the siting process, involves the communities from the very beginning and publicizes the availability of compensation. The developer may formally consider more than one site simultaneously. He may also submit a proposal without naming any site and then use the process to locate a suitable site.

- The Department of Environmental Management conducts widely publicized Briefing Sessions that give all interested communitites and individuals an opportunity to question state officials and the developer about the proposed facility, the siting process to be followed, and protections and benefits afforded host and abutting communities.

- The Council provides Technical Assistance Grants to host and abutting communities, giving them the resources (legal, technical, or otherwise) necessary for full participation in the siting process.

- Each host community creates a Local Assessment Committee which will use these grants to study the proposed facility and to acquire additional expertise. The Committee is also responsible for negotiating a Siting Agreement with the developer.

- The developer prepares a Project Impact Report that delineates the environmental and socioeconomic impacts of the facility. It represents an expansion and strengthening of the existing environmental review process required by state law and will provide the basis for negotiations between the developer and the host community.

- A host community's Local Assessment Committee and the developer will negotiate a Siting Agreement establishing the conditions under which the facility may be built including construction, operation, safety and monitoring procedures and compensation, services, or other benefits that the developer will provide the community.

- If negotiations reach an impasse, then an Arbitration Board will design a binding settlement that conforms, as closely as possible, to the final positions of both parties. This board will consist of two members nominated by the Local Assessment Committee and the developer, respectively, and a third member agreeable to both parties or a single arbitrator agreeable to both parties.

- The Courts may review the permitting process and may strike down the capricious denial of a permit by a community.

- DEQE, the state's regulatory agency, will grant or deny necessary state permits and licenses.

The power of eminent domain is included in the Siting Act only to ensure that the land will be available at a fair price for facility development. DEM may exercise that power only after all local and state permits and licenses have been granted and only after the developer has exerted a good faith effort to acquire the land and only with the permission of the governing body of the host community.

The key to a successful siting process is the siting agreement. This agreement may provide compensation and incentives to the host community. These might include such benefits as new fire equipment, provisions for adequate road design and repair, profit sharing, facility monitoring, design and operating specifications, direct compensation to nearby residents and other benefits to assure community residents that the facility will be built and operated in a manner that will protect the health, safety and environmental resources of the host community. These provisions will be included in a contractual siting agreement between the developer the host community and affected abutting communities.

An example of a compensation package resulted from negotiations between the Wes-Con Company and the host community. Wes-Con donated salvage from its site to the town, loaned mechanical equipment to local farmers, gave the town its own fire

engine, ran first aid classes for local doctors and residents and, finally, created a local corporation with local owners to run Wes-Con.

This process is designed to reduce local opposition to proposed facilities because communities are not simply required to say "yes" or "no". Instead, communities may respond to a proposal including both the facility and a package of incentives and compensation that offsets the local costs to the community. This package is negotiated by the Local Assessment Committee directly with the developer in response to the communities particular concerns. These negotiations should expedite the approval and construction of environmentally sound hazardous waste processing and disposal facilities.

If negotiations become deadlocked, the Council may submit unresolved issues to an Arbitration Board. The Board is responsible for resolving disputes based on the interests and concerns of all the parties. The determination of the Board is binding.

III. Goals and Objectives of the Bureau of Solid Waste Disposal

Economically viable technologies exist for safe and environmentally sound processing and disposal of hazardous wastes. A hazardous waste facility need not pose any greater risk than conventional industries operating in compliance with environmental regulations. The environmental and health disasters of the past are the result of inadequate recognition of the dangers and consequent failure to utilize adequate technology in hazardous waste disposal.

All the citizens of the Commonwealth benefit in some way from the many industrial activities which, unfortunately, produce hazardous wastes as a result of normal operations. Hazardous wastes are created by a variety of sources including: government, schools, hospitals, research labs, and such industries as electronics, plastics, plating, chemicals, textiles, and leather products. Eighty percent of the hazardous waste in Massachusetts is generated by small and moderate size businesses, many of whom lack on-site treatment facilities.

At present, there are adequate hazardous waste disposal services available to take care of the demand in Massachusetts. These services purify and recycle oils and solvents, dispose of some combustible materials by incineration, and provide some chemical treatment to detoxify wastes. But the major fraction of hazardous waste handled by disposal services in the Commonwealth is simply transported out of state to incinerators, treatment facilities and secure landfills in other areas.

This is not a viable long term solution for Massachusetts. Two ominous trends are visible: (1) facilities, especially landfills, that have been available out-of-state, are becoming overloaded or are being closed; (2) costs for disposal out-of-state, with no local price competition, are increasing very rapidly. Excessive costs can create incentives for Massachusetts industry to move elsewhere. If, in the future, out-of-state facilities for hazardous waste become unavailable, local industries will have to shut down, and their employees will be put out of work.

The conclusion is obvious. In the not too distant future we must have hazardous waste facilities within the Commonwealth, perhaps augmented by some out-of-state facilities developed on a cooperative, regional basis with nearby states. Since the approval and construction of a new facility takes approximately five years, it is important that the planning and siting of new facilities begin at once.

In the interim, waste generators will have to depend upon existing services, some possible expansion of the limited in-state treatment and storage facilities, and the efforts of industry to reduce the amount of waste to be handled off-site by process modification and expansion of on-site treatment facilities. It is hoped that these measures will provide adequate capacity until new facilities come on stream. Any delay in bringing new hazardous waste disposal facilities on line will seriously increase the possibility of a severe economic dislocation in the Commonwealth.

The Bureau believes that illegal hazardous waste disposal will be eliminated. It is clear that poisoning the drinking water of our children is not an acceptable alternative to facing the hard decisions and costs of proper hazardous waste disposal.

There are private developers willing to build proper and safe hazardous waste processing and disposal facilities in the Commonwealth. However, they will only commit their capital in Massachusetts under the following conditions: (1) there is a demand for disposal services from generators of hazardous waste willing to pay the costs of proper disposal. (2) site approval and related permits can be obtained without excessive delay and costs for legal battles.

The demand for services for proper disposal of hazardous waste depends upon strict regulation and enforcement. There is no cheap way out. Either the generator pays or the public pays in damage to health and the environment. The Department of Environmental Quality Engineering is pledged to do its duty strictly and

impartially. It will be immensely aided in protecting the public good if there is general support for punishing illegal disposers and if people are alert to report any observation of illegal dumping by roadsides, in the woods, or in rivers and streams.

A processor must have acceptance by the community to obtain a site for a new facility. No one will be protected if every community says "Let some other area handle hazardous wastes." Reason will eventually prevail over blind fear. The problem is time. Sites must be identified soon in order to prevent severe damage to our industry or to our health and to our environment.

Thus it is the responsibility of the Bureau, of the government in general, and of every citizen of Massachusetts to become informed about hazardous waste. We must educate others and develop the ability to make rational decisions. Safe, properly operated hazardous waste facilities exist in many parts of the world. They have no greater environmental impact than many manufacturing plants that now exist in the Commonwealth. European and Japanese communities recognize that such facilities are the vital barrier between hazardous waste industrial discharges and damage to public health. If they consider the problem logically, Massachusetts communities will realize that in accepting a hazardous waste facility under the beneficial terms specified in the Siting Act they have far more to gain than to lose. Only then, will an adequate number of sites be available in the Commonwealth.

IV. Purposes and Uses of This Document

The purpose of this report is to emphasize the critical need for additional hazardous waste management facilities in Massachusetts, describe the process whereby new facilities will be sited and to give the reader some basic information on the alternatives for treating, processing and disposing of hazardous wastes. It is written to assist facility operators and community leaders to find "the common ground" within which siting agreements can be reached. This document also includes:

- the types of technologies available for the treatment, processing and disposal of hazardous waste
- the impacts, both favorable and adverse, resulting from the use of each type of technology
- actions which might be taken to avoid dangers, minimize risks, or remedy unavoidable consequences
- the existing rules, regulations, procedures and standards which

have been established to protect public health, public safety, and the environment

- the sources and types of hazardous waste generated in the Commonwealth, the adequacy of existing facilities for the treatment, processing and disposal of hazardous waste, and the additional facility capacity needed in order to eliminate the shortfall in capacity that appears to exist.

This document can be used by developers, community officials and concerned citizens:

- to better understand the State siting process

- to identify state and federal agencies that may be of assistance to them

- to find additional information that may be useful in negotiating a siting agreement.

There are alternatives to simply opposing new hazardous waste facilities. Any community faced with deciding to support or reject a proposed facility should be better able to protect its interests by understanding the alternatives available.

V. Outline of Information Contained in this Report

Chapter 1 of this report is designed to give the reader an overview of the Massachusetts siting process, the goals of the legislature in adopting the new Act and the objectives of the Department of Environmental Management and the Bureau of Solid Waste Disposal in implementing the Act.

Chapter 2 gives the reader an introduction to hazardous waste management technology. This includes the definition of hazardous wastes and a discussion of the typical sources of hazardous wastes. This chapter also discusses methodology for dealing with hazardous wastes:

- by reducing wastes at the source through process change, waste exchange, recycling or energy recovery

- by waste management technologies (liquid organics recovery, solidification, detoxification, incineration, secure landfill).

In discussing each technology, the report describes facility operation, potential impacts and ways to minimize potential risks.

Chapter 3 reviews the legal framework for hazardous waste management

in Massachusetts. This chapter reviews existing state and federal laws, regulations and procedures for siting hazardous waste disposal facilities and for the protection of public health and the environment.

Chapter 4 discusses the general objectives of the state in protecting public health and the role of the community in controlling the location, design and operation at a hazardous waste management facility. This chapter also outlines the novel practical and legal concepts developed in Massachusetts for the construction of new facilities and describes the benefits and protective mechanisms available to host communities and to abutting communities through negotiation and compensation.

Chapter 5 provides the reader with an assessment of the types and sources of hazardous waste currently being generated in Massachusetts. It also lists the existing capacity of each waste management facility currently located in the State. This chapter also presents estimates of the additional capacity required to adequately treat current and projected volumes of waste in order to protect public health.

The appendices include technical support information that suppliments the discussion of treatment alternatives in Chapter 2. Also included is a bibliography and a cross-referenced index so that the reader can quickly find additional information on any particular point or question.

Chapter 2: Hazardous Waste Management Technology

Summary

Industrial wastes come from the production of necessities and contain the same materials as many household items. It is improper handling that makes these materials hazardous.

Technologies already exist for safe hazardous waste management. Proper management includes some combination of source reduction, recycling, on-site and off-site treatment, and secure landfill.

Each treatment and disposal process is operated with preventive controls and mitigation measures to protect public health and the environment. Many of these engineered controls and safety practices are similar to those used in industries across Massachusetts.

Many companies are responding to rising treatment costs by instituting waste reduction practices such as improved production control and material substitutions. Companies may also participate in a waste exchange where their waste is offered to companies with uses for the material. EPA estimates that 3-5 percent of all industrial waste can be recycled in this fashion.

If a plant cannot practice on-site recovery, off-site facilities may make recycling a practical option. Solvent reclamation and the recovering of energy from waste oils are two common examples of recycling.

Detoxification can render waste completely harmless. Neutralization of acidic wastes and the precipitation of the dissolved metals from aqueous wastes are the most common treatment processes.

Most organic chemical compounds can be incinerated by controlled burning in specially designed kilns, furnaces, or boilers. Gaseous emissions from this process are principally harmless carbon dioxide and water. Dusts carried by the gas stream are removed by standard process equipment. The small amount of residual ash can be buried in a secure landfill.

Solidification immobilizes liquids, sludges or semi-solid wastes into a form that limits the release of hazardous materials into the environment. This process is still developmental and is thought to be applicable to inorganic wastes. Secure landfills isolate non-liquid chemical wastes. Federal and state regulations, strictly enforced, assure safe construction and operation.

I. Definition of Hazardous Waste

The Resource Recovery and Conservation Act (RCRA) defines a hazardous waste as a waste that may cause or significantly contribute to serious illness or death, or that poses a substantial threat to human health or the environment when improperly managed. Nuclear and radioactive waste is, however, excluded from RCRA regulation. This all encompassing definition may include, among other things, road salt. When road salt is improperly stored outdoors, sodium may leach from the pile during rainfall and make its way into the groundwater. Many towns depend on these groundwater supplies as a source of drinking water. Many people have health problems that require them to be on low sodium diets. In 1979, 57 communities in Massachusetts showed sodium levels higher than the standard set by DEQE. Although the problem is real, one rarely thinks of road salt as a hazardous waste.

The U.S. Environmental Protection Agency (EPA) has established criteria for determining if a waste is hazardous. Waste materials having one or more of the following characteristics are hazardous:

- Ignitability, wastes that pose a fire hazard

- Corrosivity, wastes requiring special containers because of their ability to corrode standard materials or require segregation from other waste

- Reactivity, wastes that tend to react spontaneously, to react vigorously with air or water, to be unstable to shock or heat, to generate toxic gases, or to explode

- Toxicity, wastes that release certain toxicants above a specified concentration, as determined by a prescribed extraction procedure.

The EPA also lists nearly 500 wastes that have been determined to be hazardous and makes regular additions to this list.

There has been much discussion about whether different classes of hazard should be specified. For example, dioxin, an inadvertent contaminant found in some herbicides made under now obsolete manufacturing techniques, is toxic at less than one part per million.

On the other hand, emulsions of oil and water used with machine tools would have little impact if a drum were spilled on Main Street. At present, however, EPA does not differentiate degree of toxicity in most regulations.

It is clear from these definitions of hazardous waste that many commonly used materials are included. Only a small fraction are carcinogenic or intensely poisonous. In the past, we have often disposed of these wastes carelessly and the environment, which has a large capacity for dilution and neutralization of such materials, has absorbed them, and the effects are only now becoming evident. We now realize that significant damage has often been done and that our careless practices could be catastrophic if continued.

II. Generic Sources of Waste

Hazardous wastes are a product of our entire industrial society. Some of the manufacturing processes that generate hazardous waste produce drugs and medicines to protect our health, fertilizers and pesticides to increase our food supplies and materials and fibers to provide us with clothing, shelter and countless essentials. Other wastes are generated in the production of commodities that are so much a part of the American scene -- blue jeans, television sets, cars, telephones, leather -- it is hard to imagine our world without them.

Take, for instance, the electric coffee pot in your home. It has probably been plated with tin, silver, chrome or some other metal, as are countless other items that all of us use daily. Electroplating is a large industry in Massachusetts. In the process of electroplating many potentially harmful chemicals, such as cyanide, sulfuric acid and nitric acid are used with metals like chromium, nickel and copper. Some fraction of these materials inevitably ends up in waste streams. The following table shows a list of familiar products and the wastes generated in their manufacture.

Most manufacturing operations and many service industries produce hazardous wastes. According to an EPA study, seven industries produce 90 percent of the total in the U.S. In order of quantity produced, they are:

Primary metals
Organic chemicals
Electroplating
Inorganic chemicals
Textiles
Petroleum refining
Rubber and plastics

Although not directly regulated by RCRA, individuals also dispose of hazardous wastes. Many of the materials discarded from the home such as unused paint, drain cleaners, automobile engine oil, fluorescent light starters, varnish, household cleansers and lighter

THE PRODUCTS WE USE:		THE POTENTIALLY HAZARDOUS WASTES GENERATED DURING THE MANUFACTURING PROCESS:
Plastics	----------	Organic chlorine compounds, Organic sludges
Pesticides	----------	Organic chlorine compounds, organic phosphate compounds, organic sludges
Medicines	----------	Organic solvents and residues, heavy metals (e.g., mercury, nickel) in solution
Paints	----------	Heavy metal solutions, pigments, solvents, organic solid or viscous residues
Metal products	----------	Heavy metals, fluorides, and cyanides in solution; acid and alkaline solutions; solvents, pigments, abrasives, oils, and phenols; aqueous metal-containing sludges
Leather	----------	Heavy metal solutions, solvents
Textiles	----------	Heavy metal solutions, dyes, organic chlorine compounds, solvents

fluids contain the same materials found in industrial wastes. In many areas where groundwater contamination has been severe, the source of contamination has been traced to the use of some septic tank cleaners. Many of these products are used without regard to handling precautions. In many instances, the biggest hazard in hazardous waste is not the wastes themselves, but how they are managed.

III. Managing Hazardous Wastes

It will always be necessary to deal with hazardous waste unless we return to a stone age culture. Fortunately, the technology is available to manage such wastes so that they present no threat to human health or the environment.

There are several options for the management of hazardous waste:

- Reduction at the source

  a) minimizing amounts of waste generated by modifying the industrial process

  b) on-site recycling -- segregation and purifying waste streams so that some wastes can be used as raw materials or burned to recover energy

  c) on-site processing -- treatment to make the waste non-hazardous

- waste exchange -- transferring the waste to another industry that can utilize it

- off-site processing or recycling

- secure landfill -- disposing of irreducible residues by permanent storage in a secure landfill. In Massachusetts this is the technology of last resort.

Reduction at the source is the most desirable of the above options. In the past many industrial processes were designed with little regard for the waste production because waste disposal was so inexpensive. Therefore, there is considerable room for process improvement. Some have estimated that after these improvements are made, an additional 50 percent of hazardous waste can be eliminated. On-site recycling and on-site processing can probably be used economically to take care of another 20 to 30 percent of the waste. There is strong corporate motivation to reduce wastes at the source. This eliminates a large part of the high off-site disposal costs and eliminates the possible liability of the generator due to malfeasance by the off-site disposal company.

Waste exchange is carried out by the maintenance of a catalogue of available wastes which is distributed to

to potential industrial users. While this is a useful approach, in practice, rarely as much as 5 percent of the available waste is utilized.

The remaining wastes, that need to be handled off-site, are most effectively disposed of in the following ways:

- contaminated oils and solvents -- purified by filtration, phase separation, or distillation either to be re-used or burned as fuel

- aqueous sludges -- filtered, dried or calcined to remove water; a solidified, treated product appropriately landfilled

- aqueous chemical solutions (e.g., plating wastes) -- cyanides decomposed to water, carbon dioxide and nitrogen by oxidation; acids and bases neutralized; heavy metals precipitated and recycled

- non-combustible solid wastes -- to secure landfill.

The plants used for processing hazardous wastes are similar to small to medium sized chemical manufacturing plants and will have no greater environmental impact. A secure landfill for hazardous waste, if properly designed, constructed and operated, will have no more enviromental impact than a municipal waste landfill.

IV. Methods to Reduce Waste at the Source

Waste reduction and on-site recovery or processing are often highly cost effective. As costs of raw materials and of off-site treatment and disposal increase, this waste management option will be even more advantageous.

There are many ways that the amount of hazardous waste being generated can be reduced. A simple example is better production control to minimize the generation of batches of product which fail to meet quality control specifications and, therefore, cannot be sold. Some companies have had to dispose of large quantities of chemicals and other products which are only marginally outside the technical specifications required for sale.

Another approach to reducing hazardous waste is to change the nature of the material used in the process to one which is less difficult to dispose of or treat. Examples include the use of some heat treatment salts which do not include cyanide in their composition and the gradual replacement of polychlorinated biphyenyl (PCB) products in electrical equipment. These processes can offer a company considerable financial advantage if the company looks at the total cost of production including waste disposal rather

than regarding waste disposal as a general overhead item.

Another relatively simple approach which industries may adopt is to segregate certain wastes that are difficult to dispose of from those that can be handled with nonhazardous waste. This reduces the bulk of material needing special handling.

Finally, an industry may actually alter its manufacturing process by using a low- or non-waste technology. The U.S. Department of Commerce is assisting the United Nations Commission for Europe to locate these technologies. This program seeks to reduce energy and resources consumption and to minimize or eliminate adverse environmental effects. The U.N. group has recently published a compendium which provides a source for industrial planners to obtain information on new processes and equipment. (More details on this compendium are found in the Appendix.)

Recently, the metal finishing industry has been looking at the "Providence Method" for source reduction. This method was developed by the Manufacturing Jewelers Association in cooperation with the firm of J.E. Thibault and Associates. The development was funded by the Department of Commerce. There are two elements in the Providence Method -- waste containment and water reduction. Waste containment modifies the process to use distinct separate rinses flowing at different rates in order to contain all toxic materials associated with the process in small, concentrated volumes. While additional rinse water is necessary, it is only for product cleanliness and need not be contaminated with toxics. Because these special rinses are so concentrated, an electrochemical process can often be used to recover the metals and destroy any cyanide at the same time. Conventional methods of reducing flowing rinses used for product cleanliness are a second step in this process. This step alone can reduce the water use and the amount of aqueous wastes requiring treatment by 30-40 percent.

Besides the technologies described above, which actually reduce waste generation, there is the possibility of on-site recycling or recovery or on-site treatment. For the latter, the off-site waste management technologies described below are all applicable.

On-site recycling or recovery involves re-use of the waste material. Energy is the most common ingredient of waste to be recovered, and oils and combustible solvents are being increasingly burned in on-site equipment for their heating value. Clean up of solvents by distillation; regeneration of spent hydrochloric acid by thermal process; and remelting of metal dusts are examples of on-site recycling.

V. Waste Exchange

Waste exchange or the transfer of a hazardous waste to another industry is an alternative to source reduction that is receiving increasing attention. Operating on the principle that one company's waste may be another company's raw materials, this option can take two basic forms:

- Materials exchange, where the sources are equiped to handle, treat, and physically exchange wastes;

- Information exchange, which acts only as a clearinghouse, leaving the generator and potential purchasers to negotiate directly.

Waste exchanges have been operating in Europe since 1972 and have begun to spread to the United States. At least 20 information exchanges and three materials exchanges are now in operation in this country. The first information exchange in the United States was established in 1975 by the St. Louis Regional Commerce and Growth Association. Typically, information exchanges are often run by a non-profit organization or by a local Chamber of Commerce. In contrast, materials exchanges are usually commercially operated for profit.

Only a small percentage of hazardous waste is directly suitable for exchange. Less contaminated wastes that include many "off-spec" materials stand the best chance of being exchanged. Also, waste is more likely to be exchanged with the purchaser who is in the same or nearby locality, which minimizes transportation costs. Waste exchange, though not a panacea, makes a valuable contribution to the hazardous waste problem by reducing the amounts of material to be managed by less desirable options. EPA estimates that 3-5 percent of all industrial wastes could be recycled in this fashion.

VI. Off-Site Waste Management Technologies

If the waste cannot be exchanged or eliminated completely at the source, there is a residue that must be moved to an off-site waste management facility. Chemical, thermal, or physical treatment to destroy the waste or make it non-hazardous or less hazardous is the preferred approach. These methods and the types of waste they handle are summarized in the table on the next page.

Each of these technologies is discussed in the rest of this chapter. The processes are outlined and costs for waste treatment estimated. A typical facility for each technology is described and pictured. The environmental impact and means of mitigating

EXAMPLES OF OFF-SITE MANAGEMENT
FOR DIFFERENT WASTES

	Recycling/ Reuse	Detoxi- fication	Incin- eration	Solidifi- cation	Secure Landfill
Motor Oils	x		x		
Industrial Oils & Emulsions	x		x		
Solvents, Lacquers, etc.	x		x		
Organic Chemicals & Misc.			x		
Aqueous Organic Chemicals		x			
Aqueous Inorganic Chemicals		x		x	
Cyanide, Plating Wastes		x			
Solid Chemicals	x			x	x
Clay & Filter Media				x	x
Plating Sludge	x			x	x
Oily Solids			x		
Reactive Materials		x			
Cylinders, Explosives		x	x		
Pesticides		x	x		

it are presented.

Each facility for hazardous waste management has some environmental impact. The minimum is simply an object on the landscape, but gaseous emissions, noise, traffic, and fire hazard are all possible. Such impacts are carefully minimized and controlled in modern hazardous waste treatment facilities.

Recycling/Reuse

The most profitable part of the hazardous waste disposal business (from the processor's viewpoint) is the recovery of materials or energy. The processor can only with difficulty obtain a sufficiently high price from the waste generator to cover the cost of proper waste destruction. He can often make money on recycling. Thus, the most successful businesses in hazardous waste disposal are those that handle waste oils and solvents, which are easily cleaned up for recycling or can be burned as fuel.

There are other recycling processes, however. Bare metal refining, plating, or forming plants sometimes have dilute aqueous waste streams containing copper or nickel. A small industry exists to recover these metals from such waste. Acidic pickle liquor from metal finishing operations may be used to remove pollutants in municipal sewage treatment plants.

Fuel use of waste materials with high energy content is, of course, an increasingly desirable option. The easiest way to make use of contaminated or impure organic materials for this purpose is to burn them where the impurities will not create a problem in the furnace or produce dangerous gas emissions. The cement industry is a nearly ideal application. The huge cement kilns operating at high temperature effectively destroy even chlorinated solvents. Heavy metal contaminants, if present, are permanently locked up in the cement. Other industrial processes can use contaminated fuels. Thus, recently EPA has permitted oils contaminated with up to 50 ppm PCBs (polychlorinated biphenyls) to be burned in power plants.

Solvent and oil recycling provide the greatest potential for waste recovery in Massachusetts. The presence of certain substances and contaminants in many organic liquids (solvents and oils) does not allow for direct reuse or waste exchange. Available chemical engineering technologies can be utilized to reprocess and refine these materials. The three major types of organic liquid recovery operations are:

- Distillation of waste solvents
- Re-refining of waste oils

- Blending of waste solvents to produce supplemental (synthetic) boiler fuels.

In the distillation process, volatile mixtures of oils or solvents, possibly also contaminated with non-volatile dissolved solids, are heated to boil off a purer vapor. This vapor is condensed for re-use. Generally, the less volatile residue must be incinerated. In some cases its heat value is recoverable.

Waste oils are "re-refined" by essentially a purification process. Chemicals are added to precipitate impurities, clay is added to absorb impurities, water is physically separated and volatile impurities are distilled off.

Facilities and Their Impact

The facilities for recycling of oils and solvents often appear similar to a small chemical plant. In a climate as cold as New England, treatment tanks are usually indoors, but for ease of construction and repair access distillation equipment is usually exposed in a steel frame open structure. There will usually be included:

A. Laboratory/office building

B. Trucks unloading dock

C. Storage warehouse for drums

D. Distillation facilities

E. Small incinerator (supplying steam for distillation and facility heating)

F. Storage tanks

Such a facility is pictured on the following page.

The environmental impact of this type facility (other than visual) includes:

1. Potential spills

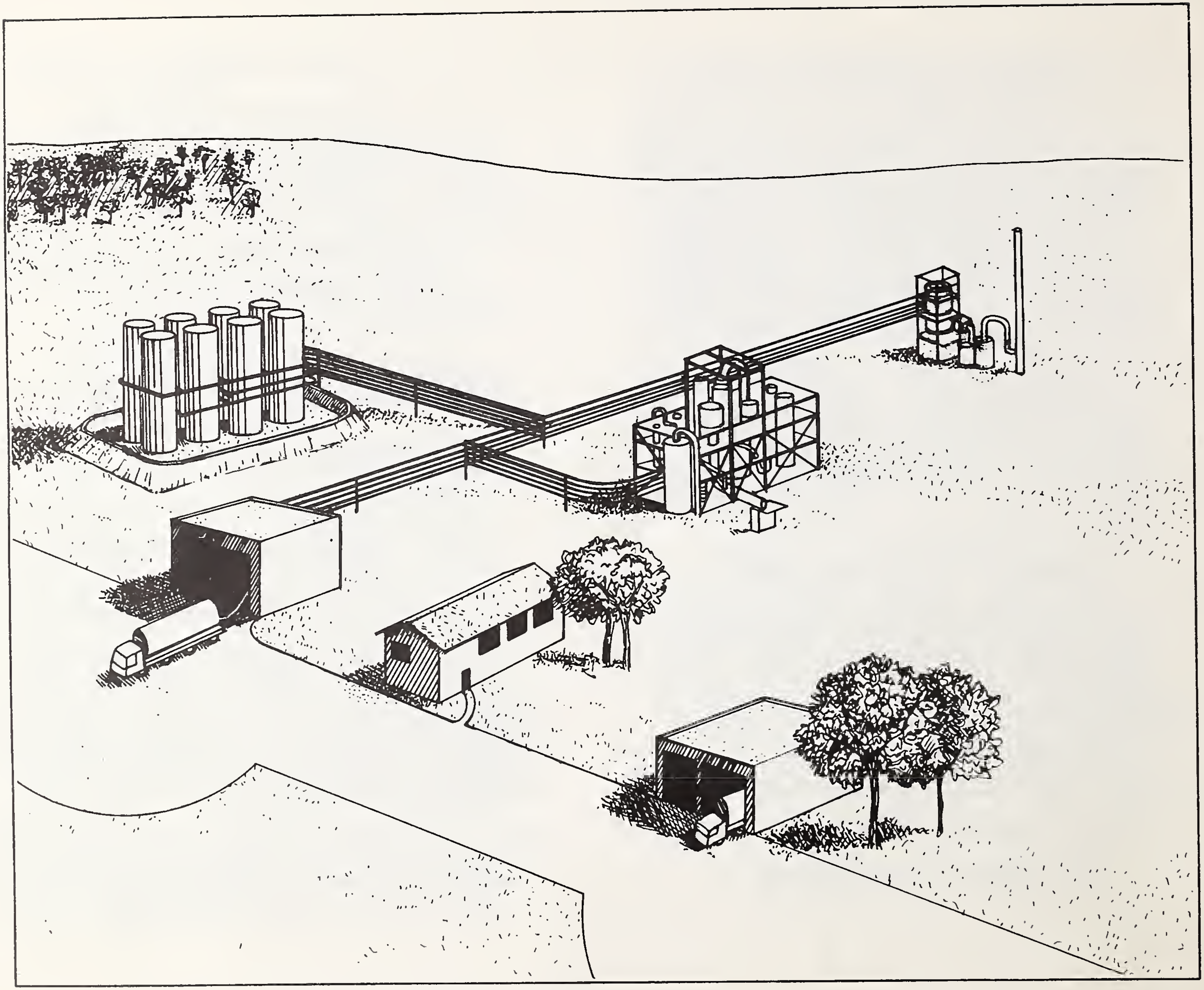
2. Traffic

3. Gaseous or particulate emissions

4. Fire and explosion hazard

Potential spills. These occur principally in the area of truck unloading. Here tank trucks are unloaded via connecting flexible hoses, as with home oil delivery. Truckloads of drums are generally handled on a four drum pallet by forklift.

To reduce spilling, careful connection and disconnection of unloading hoses and sealing of drums are the most important control procedures.



OIL AND SOLVENT RECYCLING FACILITY

To lessen the effect of spills, the area is covered with concrete and drains provided whence liquids can be safely pumped to a storage tank.

Spills can also occur from failure of lines or tanks. This is rare if the plant is well managed. However, for tanks, catchment areas are provided so that amounts of liquids cannot flow off the property.

Traffic. Traffic inevitably increases when any industrial plant is sited. The effect can be mitigated by siting in an area already devoted to industry near major highways and, if necessary, by building special by-pass roads. Night delivery is not generally necessary and can be restricted.

Gaseous or particulate emissions. Many solvents and oils emit a chemical odor. If contained in pipes and tanks or other closed equipment, this is suppressed. Spills are a problem but should be made infrequent by good management and when they occur, rapidly washed down the drain.

An incinerator can emit an odor if combustion is incomplete or chlorinated solvents are incinerated. Such odors are removed by gas treatment equipment, scrubbers or packed absorption beds.

Particulate emissions are not common with the combustion of oil or solvent residues. Scrubbers also remove particulates and an electrostatic precipitator can be added, if the problem is severe.

Fire and explosion hazard. Such hazards exist wherever organic liquids are stored or handled. However, we have learned to deal with this problem so well that gasoline is stored in large quantities and can be transported and distributed in every community.

Control of this hazard involves proper industrial techniques. The facility should be sited away from houses, proper explosion-proof construction for wiring is used, fire extinguishing equipment is installed, catchment basins prevent flow of a burning liquid, and alarms alert plant personnel.

A solvent and oil recovery facility is very small compared to a refinery or even to a gasoline storage facility, such as the many around Massachusetts. If properly constructed, the facility will present insignificant hazard. Unfortunately, in the past there have been improper operations in this and other states.

Cost

The capital investment in an oil and solvent recycling facility typically

ranges from $1 million to $15 million. A facility as described and pictured above would be in the several million dollar class.

Users of a recycling service for oils and solvents usually pay nothing or receive a small payment for their waste, say 5¢ to 25¢ per gallon.

Detoxification

Aqueous wastes, in particular, can be detoxified by relatively simple treatment processes. Such treatment can either render the material completely innocuous or substantially reduce the volume that must be disposed of directly to the land. This is a crucial concern because the land available for disposal is decreasing in the face of increasing waste tonnages. Lately, increased attention to the development of improved and less expensive treatment technologies has greatly increased the utilization of this option.

Many equipment and process vendors are offering package units and training programs which will enable many waste generators to treat their wastes at the plant so that no hazardous wastes will have to be transported off the premises.

There are three types of processes used to render a hazardous waste less hazardous or nonhazardous:

- physical processes that separate out the hazardous component or change the physical form of the waste to make it less toxic
- chemical processes that utilize chemical reactions to alter the waste
- biological processes that utilize microorganisms to destroy toxic organic materials.

The following table shows the different types of chemical, physical and biological treatment processes and examples of wastes treated by each one.

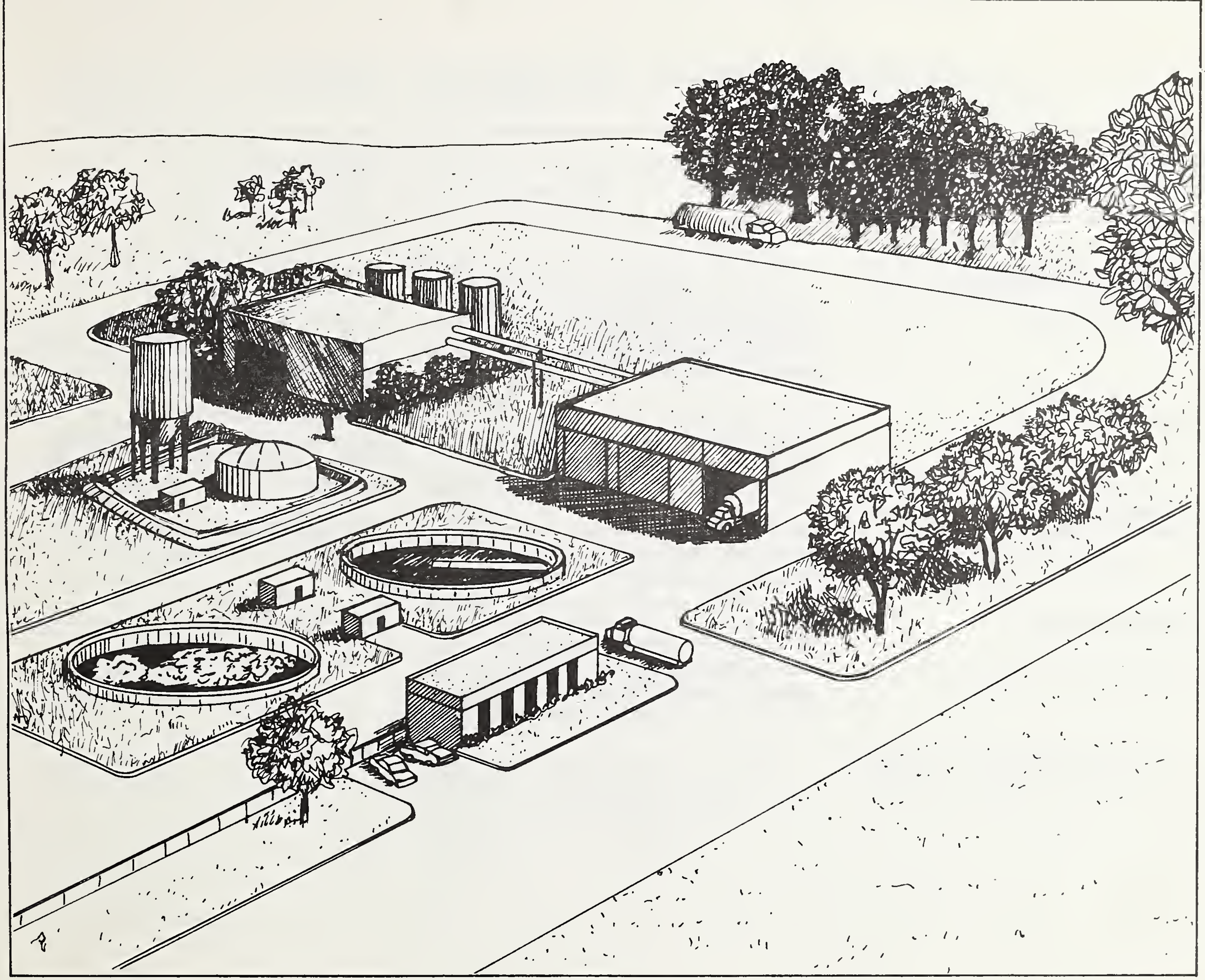
Facilities and Their Impact

Detoxification facilities are compact and environmentally rather innocuous. In a cold climate most or all of the equipment is installed in closed buildings. The exception may be a bank of storage tanks and open wastewater treatment tanks buried in the ground. Because the facility handles aqueous wastes, there is extremely low fire hazard, less than in a home.

A typical facility is shown in the drawing on the following page. Included are:

A. Laboratory/office building

B. Treatment buildings (containing tanks, pipelines, pumps and filters)



AQUEOUS WASTE DETOXIFICATION FACILITY

TYPES OF CHEMICAL, PHYSICAL AND BIOLOGICAL TREATMENT

Type of Treatment	Description of Process	Examples of Wastes Treated
<u>Chemical Treatment</u>		
Neutralization	Neutralizing agents are reacted with wastes to adjust the pH level	Acids and alkaline solutions from chemical, metal finishing and plating industries
Oxidation	Mixing of an oxidizing agent with waste to form an innocuous product	Cyanide solutions from electroplating industry also toxic organics in aqueous solution
Coagulation	Destabilization and aggregation of smaller particles to make settling easier	Colloids and latexes
Precipitation	Addition of chemicals to make heavy metal consituents insoluble thereby causing separation from a solution or suspension	Electroplating wastes

Type of Treatment	Description of of Process	Examples of Wastes Treated
Reduction	Reduce the oxidation state of a material	Hexavalent chromium salt solutions especially from leather tanning industry
Chemical Adsorption or Ion Exchange	Passing solution containing contaminants through columns containing activated carbon or ion-exchangers which hold onto the contaminants and allow the water to pass through	Aqueous organic wastewaters and electroplating rinse waters
<u>Physical Treatment</u>		
Sedimentation	Removal of settled suspended solids	Post treatment step for aqueous waste treatments
Distillation	Boiling a mixture of liquids to extract a vapor of the lower boiling components	Halogenated and non-halogenated solvents
Evaporation	Concentration of solids by boiling off the solvent (volume reduction)	Rinse waters from metalplating
Flotation	Floating materials to the surface by attaching them to air bubbles and then skimming the surface	Organic contaminants in aqueous waste streams

Type of Treatment	Description of Process	Examples of Wastes Treated
Dewatering	Filtration of sludges to remove excess water and to reduce volume	All sludges produced in treatment
Biological Treatment		
Aerobic	Microorganisms which require oxygen for the existence are used to treat wastes	Organics, sludges, and wastewaters containing organics especially after oxidation and adsorption treatment
Anerobic	Microorganisms which do not require oxygen for their existence are used to treat wastes	High concentration organic waste

C. Storage tanks

D. Aeration tanks and thickeners for biologic treatment

Environmental impacts are:

1. Potential spill

2. Traffic

3. Potential odors

4. Chemical toxicity

Potential spills. Proper control of the liquids, impervious floors with drains leading to a recovery sump, and catchment basins for tanks will control spills.

Traffic. As discussed under the section entitled "Recycling/Reuse."

Potential odors. Odors arise from storage and reaction tanks if improperly vented with vent gas scrubbers. Spills can also create odors and should be rapidly flushed away.

Chemical toxicity hazard. Certain toxic chemicals are treated. The one that causes greatest concern is the cyanide in solutions used for electroplating. To put this in perspective there are dozens of electroplating plants in the Commonwealth with more concentrated cyanide solutions than found in the waste. These are located in the middle of many cities and towns. We have learned how to handle such solutions safely. In the treatment facility cyanides are decomposed by hypochlorite solution (household bleach) to form carbon dioxide, water, and nitrogen.

Costs

The capital cost of a detoxification facility is expected to be in the range of $3-6 million. Processing costs will typically range from $50-100 per ton of aqueous waste, which is typically a rather dilute solution.

Incineration.

Using today's technology, incineration can be the most effective way to dispose of hazardous organic waste. The incineration of hazardous waste involves controlled burning in a specially designed kiln, furnace, or boiler. Only wastes that will decompose upon heating are suitable for treatment by incineration. Most organic chemical compounds meet this criterion. These chemicals are made up of elements found in normal plant and animal matter. In many cases, they have been synthetically produced and modified by adding other elements such as chlorine and bromine to create molecules not found in nature. Some of these chemicals, both natural and synthetic, have properties that

make them hazardous. However, when they are incinerated, mainly carbon dioxide and water vapor are released to the environment.

Wastes that can be incinerated include distillation residues, oily wastes, chlorinated hydrocarbons, contaminated solvents, pesticides and a variety of other organic materials. Chemicals such as benzene or alcohols produce sufficient heat when incinerated to sustain the incineration process. Sometimes there is excess heat available for recovery purposes. Other materials such as chloroform, will decompose only if supplementary fuel is added.

Many equipment manufacturers offer hardware for the on-site incineration of these wastes. Some Massachusetts industries are already utilizing this method. Regional facilities incinerating a variety of wastes often blend materials with different heat content to use the excess heat available in one waste to sustain degradation of another.

There are many different incineration devices suitable for handling hazardous wastes. The most frequently used incinerators are rotary kilns and liquid injection incinerators. A rotary kiln is a slowly rotating cylindrical combustion chamber, slightly inclined to the horizontal. The rotation of the kiln during combustion continually mixes the solid and semi-solid waste material with air. This promotes uniform burning. Incinerators of this type are generally used for the destruction of solids and sludges but can also be used for incinerating some gases and liquids. Liquid injection incinerators are used to dispose only of liquid waste and slurries, i.e., pumpable mixtures of solids and fluid. These wastes must be readily combustible and must be of low viscosity. This type of incinerator may be either a verticle or horizontal unit into which the liquid waste is pumped after its conversion to a fine spray.

Wastes that are received for incineration are segregated and held in outdoor storage tanks or indoor vats. Liquids can then be pumped to the injection nozzle of the incinerator. The rotary kiln has the capability of burning solids which are generally loaded by a grab bucket on a crane. By carefully controlling the feeding process and the heat in the incinerator, the wastes are held long enough to be destroyed.

Besides the harmless gases discharged from an incinerator stack, there is a residual ash or slag amounting to about 5 percent of the weight of the solids fed. This is discharged into water and because of its high temperature the ash fragments into sand-like grains. This irreducible

waste usually contains heavy metals that would leach out and must be put into a secure landfill.

Facilities and Their Impact

A liquid incinerator is a relatively small piece of equipment. One is shown on the drawing for the solvent and oil recycling facility.

A rotary kiln incinerator, which can handle all types of solid and viscous waste as well as liquids and gases, is a much more impressive structure. It has the general features of an industrial plant boiler facility, except that the furnace in an industrial plant usually has no rotating section. Like an industrial boiler it has a tall stack. A large rotary kiln incinerator plant is shown in the drawing on the following page. This one could handle 50,000 tons per year and would be adequate for all of Massachusetts. Smaller size units are rarely built because of the greater unit cost of incineration.

The facility typically includes:

A. Laboratory/office building

B. Truck unloading station with solid waste vats inside

C. Rotary kiln system with feeding equipment, kiln, waste heat boiler, gas treatment equipment, and stack

D. Storage tanks

The environmental impact includes:

1. Potential spills (less important with solids)

2. Traffic

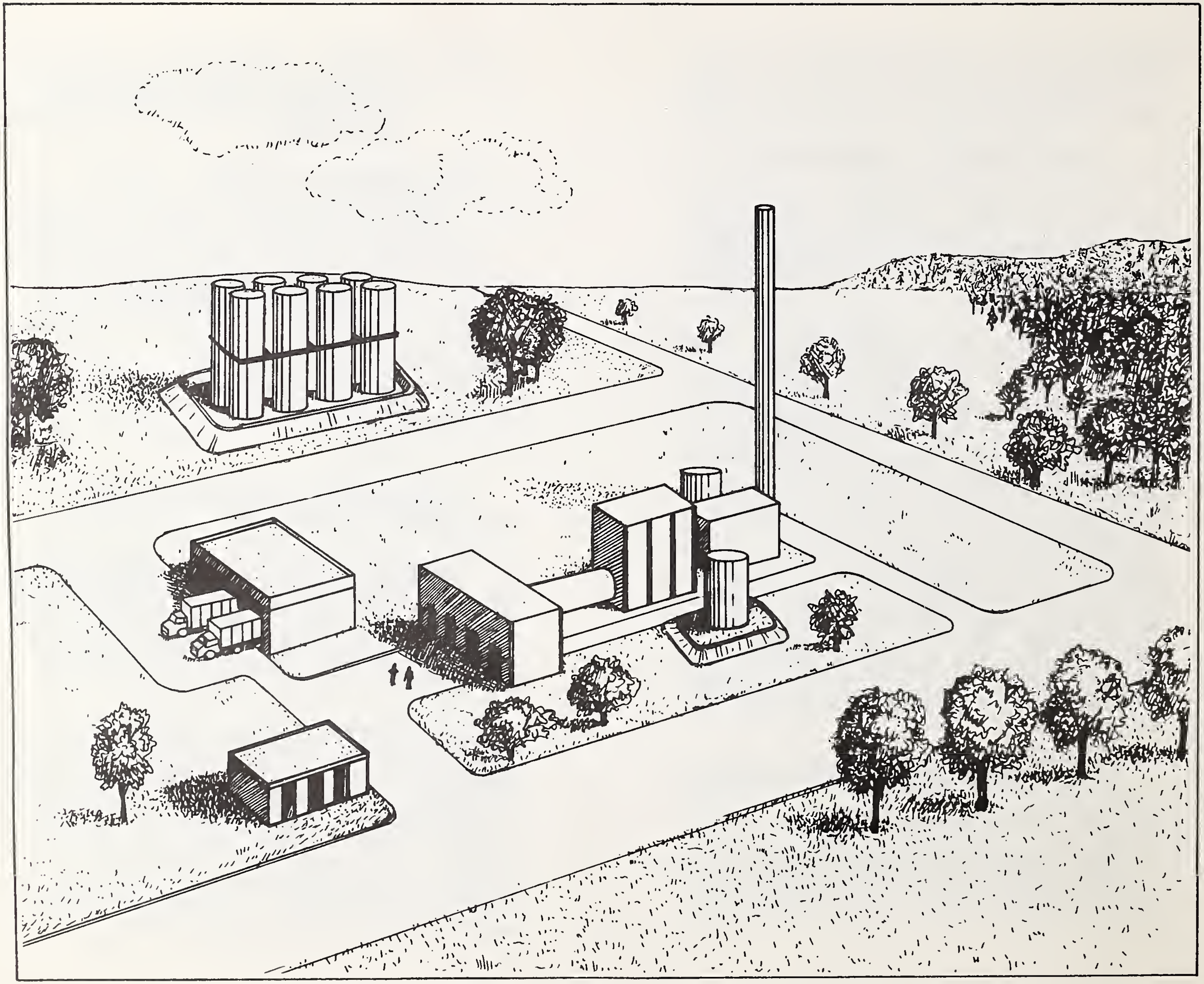
e. Gaseous and particulate emissions

4. Noise

Spills and traffic have been previously discussed.

Gaseous and particulate emissions. These are controlled by proper combustion and the use of gas scrubbers and electrostatic precipitators, two standard pieces of process equipment widely used on power plants.

All incineration functions are carefully monitored by a sophisticated control system. This system can monitor temperature conditions within the incinerator at any given time. When these conditions are not adequate for proper combustion efficiency, the feed of hazardous waste is shut off and the incinerator continues to burn gas and other supplemental fuels.



INCINERATION FACILITY FOR SOLIDS AND LIQUIDS

Backup systems are provided in case the primary system fails. The regular inspection and maintenance of these systems are part of the formalized operation of the facility. The operation and maintenance of a facility can be examined periodically by regulatory officials to determine compliance with the plant permit. Special monitoring equipment is also placed in the stack. This equipment will notify the operator if a problem has occurred that has not been picked up by the operational control system.

Noise. Operation of an incinerator produces the noise typical in a power plant. Blast air for combustion produces a low roar, machinery vibrates, and motors hum. Such a facility should only be sited in an industrial zone or in an open area away from homes. There is no way to eliminate all noise near such a facility although proper buildings enclosing equipment and architectural and natural shielding helps.

Costs

Incineration is more costly and more complex than some alternative hazardous waste management techniques. However, with the viability of this treatment option as described in the EPA regulations and with the advent of waste heat recovery, incineration will be more widely used as a cost effective approach for treatment and disposal of a large variety and volume of hazardous organic waste materials. An incineration facility is likely to cost in the $10-20 million range. It will typically cost between $80-400 per ton to incinerate hazardous wastes. However, some special low-volume wastes which are highly resistant to burning may cost over $1000 per ton to incinerate.

Solidification

Solidification is the process for treating hazardous waste in which it is mixed with a cement-like or other solid forming material to entrap the waste and prevent its components leaching into the environment. The process is applicable to liquids, sludges or semi-solid waste containing inorganic components only. It has generally not been deemed adequate for organic materials.

The success of any solidification process depends on how well the stabilized waste will resist leaching into the environment. Resistance to leaching depends on how mobile the waste component is when exposed to a leaching fluid such as rain water. Solidification generally is designed to chemically bond the contaminants. The material should have sufficient physical strength and structural integrity to remain a solid when placed in the ground.

Adequate equipment and technology are available to handle solidification

either on-site or at regional off-site facilities. There are many companies offering solidification technology on a commercial basis in the United States. The most commonly used materials for solidification are silicates, Portland cement, fly ash-lime mixtures, and asphalt.

Facilities and Their Impact

The solidification plant is not unlike a concrete mixing plant. There are no high temperatures and the process is primarily a single step mixing.

In a cold climate, equipment would be installed inside. The building would resemble a low warehouse. Some silos would be used to store the solidification ingredients, such as Portland cement.

Solidification processes are still in a developmental state. Not enough permanent facilities have been built to establish a preferred plant layout. The drawing of a solidification facility on the next page is, therefore, representative of good engineering judgment rather than being modeled on an existing site. The facility includes:

A. Laboratory/office building

B. Truck unloading

C. Process building

D. Storage silos for solidification materials

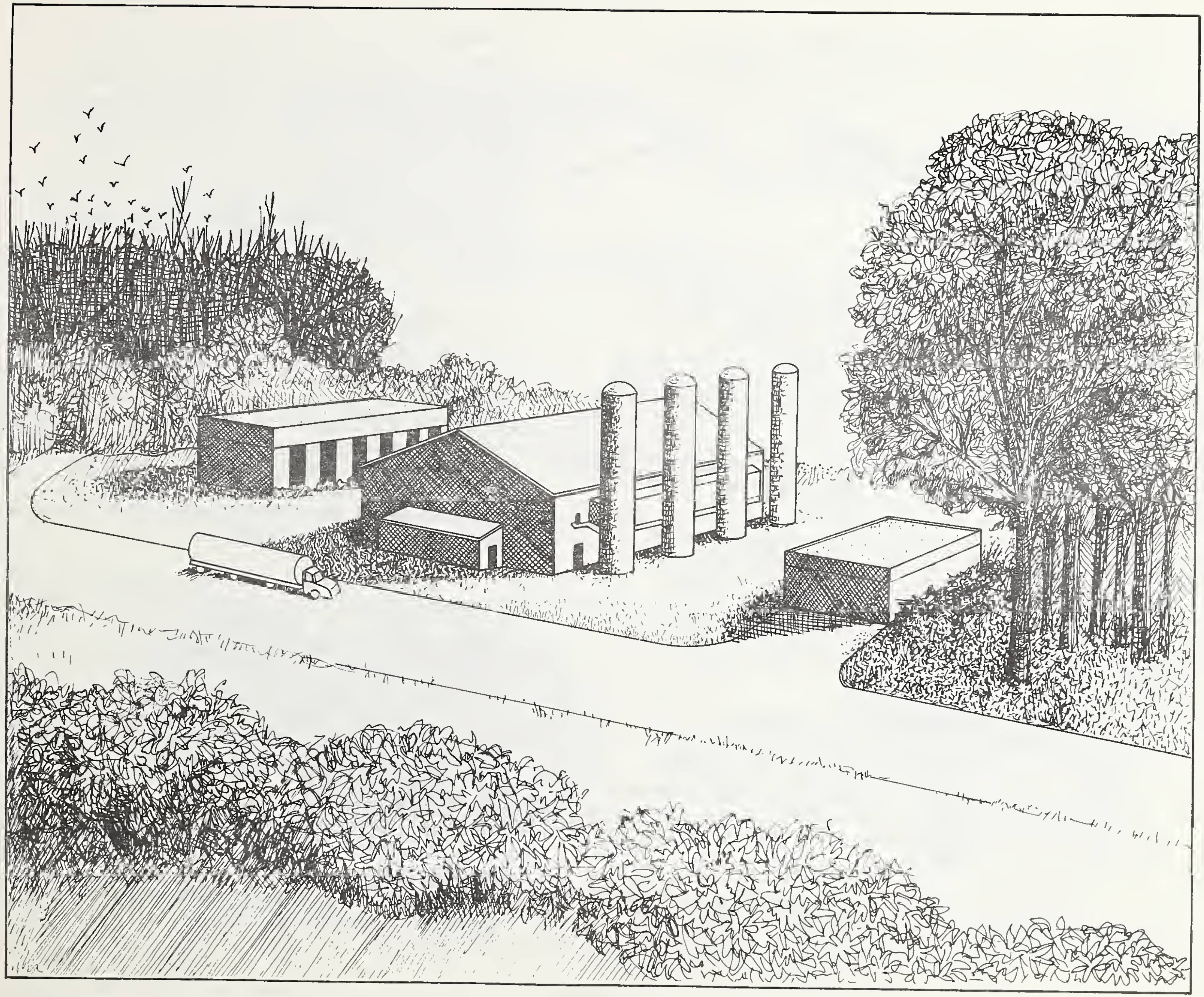
The product from the plant could resemble coarse gravel or concrete block. It would be trucked or transported by conveyor belt to a landfill, not shown in the drawing. So far in the USA, the product material must be placed in a secure landfill, as is the case for other hazardous waste. However, tests are planned on a large scale in the next two or three years to determine the stability of the solidified product. It is possible that the results will indicate that negligible amounts of toxic substances do leach out. In that case, an ordinary landfill might be possible for solidified hazardous waste disposal. Under present restrictions, the process does not have much utility.

The environmental impacts of a solidification facility include:

1. Potential spills

2. Traffic

Potential spills. This problem is much less important with solidification facilities, since only inorganic wastes that cannot be otherwise detoxified are brought in. These include chiefly solutions and sludges



SOLIDIFICATION FACILITY

of heavy metals. These are neither highly toxic nor volatile. Mitigation of spills has been previously discussed.

Traffic. This problem is similar to other facilities and has been discussed.

Cost

The capital cost of a solidification facility is expected to be between $3 million and $10 million. Processing costs can be expected to be between $10 and $100 per ton.

Secure Landfill

Up to now landfills have been used in the United States for the vast majority of all hazardous wastes removed from the generator plant site. This has included extremely toxic and carcinogenic chemicals, highly reactive materials, and oils. Such practices produced the Love Canal and other disasters and are now being stopped.

In Massachusetts, landfills can only be used as the technology of last resort for irreducible residues. This includes only inorganic substances in solid or semi-solid form, e.g., non-combustible solids and heavy metal containing sludges.

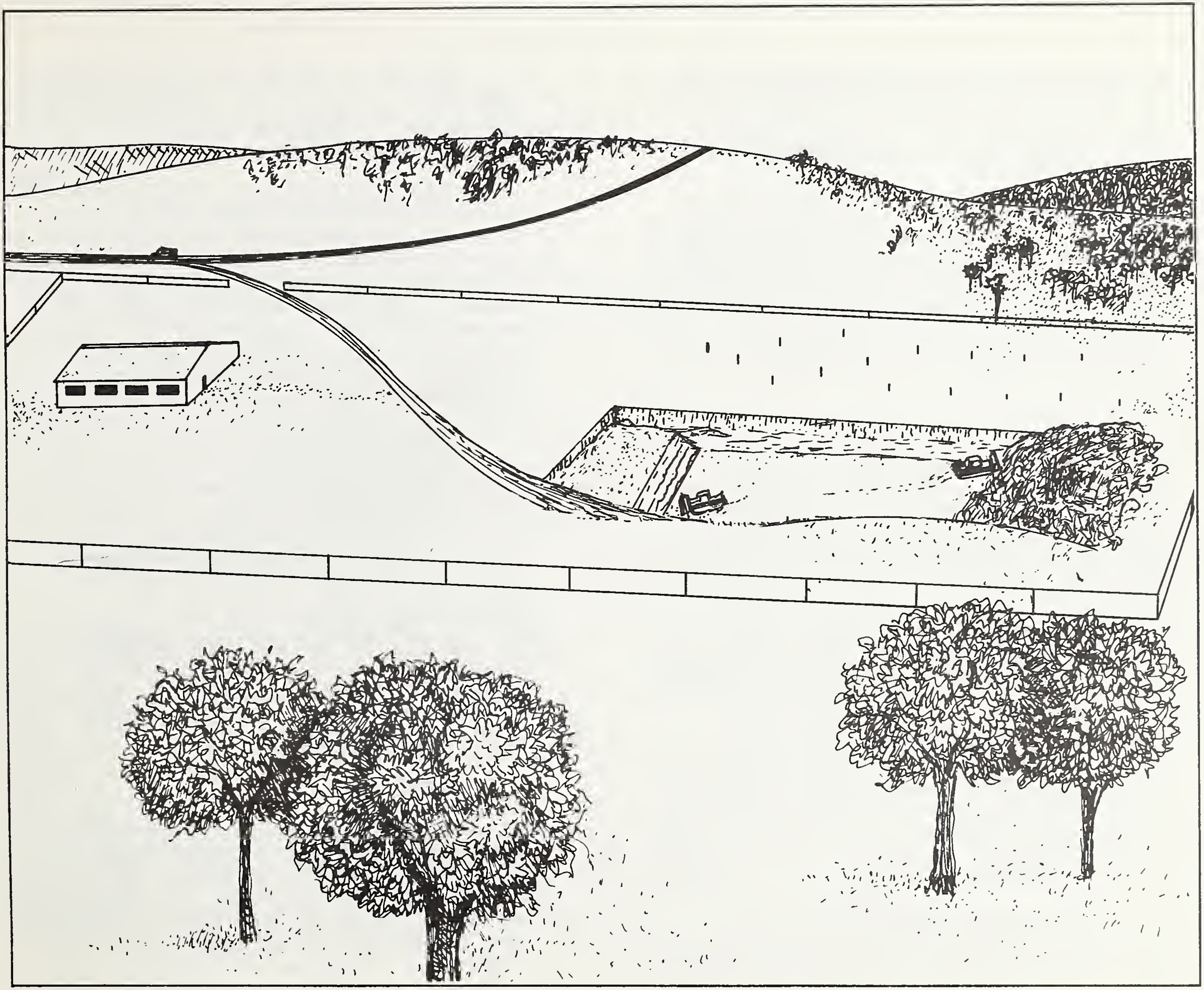
Because of past history, hazardous waste landfills are feared. Properly constructed and operated, however, they are more innocuous than the average industrial plant and when closed, look like most other parts of the landscape. They do, however, represent a a piece of land which must be permanently devoted to the purpose of waste disposal. Putting buildings on these sites, as has been done in the past, is not a good idea.

Facilities and Their Impact

A secure landfill is simply an engineered burial operation with permanent barriers between the waste and the environment. The best barrier is a thick layer of clay, something of the order of 10 feet. Such a barrier is impervious to water and would generally heal over even cracks formed by earthquakes.

A pit is dug in the clay bed and waste placed in layers about 10 feet high. A layer of clay a foot or more in thickness is then put over the waste. Another layer of waste is then added and another layer of clay. Maps of the waste that is deposited are kept. Vent pipes may be installed if there are wastes which can slowly react and emit gases.

Beneath the pit drain pipes have been installed to collect water leaching through the waste heap. This is conducted to a settling basin for testing and treatment. The purified



SECURE LANDFILL

water is discharged and impurities, usually recovered as a sludge, are put in the landfill. Test wells in the area monitor the groundwater for contamination.

When the landfill is closed a final thicker layer of clay is used to cover over the waste and a layer of loam is added. Grasses and shrubbery are then planted. The area should be fenced and restricted. It is monitored for a minimum of 30 years.

A landfill is shown in the drawing on the following page. Such a facility is possible to site in Massachusetts, although clay beds of the proper thickness are not easily found. Layers of permanent plastic sheets can be substituted for some of the clay thickness.

The landfill includes:

A. Laboratory/office building

B. The pit with heavy earth moving equipment

The environmental impact is:

1. Traffic

2. Equipment noise

3. Potential spills

4. Potential long-term leaching of toxic materials

Traffic. This is the principal impact of a landfill. Proper location and use of roads away from homes mitigates this problem.

Equipment noise. Bulldozers and front loaders are required at a landfill to dig out areas to be filled, to load in waste, and to cover it with clay and earth. Trucks are also entering, dumping, and leaving. The noise level is comparable to a construction site. Mitigation is by proper location away from homes screened by woods if possible.

Potential spills. This is not a problem in a well-run landfill. Trucks unload on-site and the potential for spills is only from overloaded trucks on the way to the site or improperly cleaned trucks departing.

Potential long-term leaching. This would occur with an improper landfill. Control of leachate by bottom drains and monitoring wells in the water table mitigate this problem, as described above.

Cost

The capital cost of a secure landfill will vary greatly with the price that must be paid for the land. In the Northeast, landfill land has sold for as much as $100,000 per acre. For a 100-acre site, therefore, the land cost would be as high as

$10 million. The capital for buildings, initial pit opening, fencing, and heavy equipment adds an additional $1-3 million. Processing costs will be $30 to $100 per ton.

The price that users of a landfill service will pay may be much higher than the costs that could be derived from the above example. A hazardous waste disposal company that intends to stay in business must consider the long-term cost of monitoring the closed landfill and build up assets to pay for this through operations. There is, of course, also the question of scarcity. With no hazardous waste landfills in New England and a shortage throughout the country, waste generators are paying $300 per ton or more just for the tipping fee, i.e., the charge at the landfill.

Transfer Stations

In Massachusetts, many wastes are generated in small volumes and are containerized at the source in drums. These wastes can vary greatly in their composition. For instance, it is not uncommon for a waste generated from a manufacturing operation to change substantially from day to day. In order to economically collect and store small volumes of wastes and mix them so that the composition changes do not upset the treatment process, a transfer facility is often used. Incoming wastes are carefully analyzed and segregated. They are usually stored in bulk containers. The wastes then can be transferred from these containers to more economical bulk carriers for transport to treatment and disposal facilities.

Facilities and Their Impact

A typical transfer station looks like a warehouse. Trucks move in and out to unload or transfer cargo. Large storage tanks are located in the rear of the facility. A number of hazardous waste management firms operate transfer facilities in Massachusetts.

The environmental impacts include:

1. Traffic

2. Potential spills

3. Potential odors

4. Fire and explosion hazard

Traffic. The transfer station is most usefully located in the industrial zone near generator industry. Thus, the traffic addition to the neighborhood is not usually significant.

Potential spills. As with a treatment facility, there is the potential for spilling as materials are unloaded and reloaded. As described above, this is mitigated by concrete aprons, dikes, drains and careful operation.

Potential odors. Odors can result from spills and from materials in storage, especially from materials

in drums that are not properly sealed. The transfer of waste from drums to bulk tankage also exposes it to the atmosphere briefly. The way to mitigate this problem is to provide indoor working space fo the transfer of material with controlled atmosphere and scrubbing of vent air.

Fire and explosion hazard. Since transfer stations typically handle solvents and oils, the fire and explosion hazard is similar to a recycling treatment facility for these materials. Its mitigation is described under the section on Recycling/Reuse above.

Costs

The cost of a transfer station will range from $200,000 to $2 million. The transfer and storage cost is typically $2 to $50 per ton. The high range results from unloading drums into bulk containers.

Transportation

Programs have been set up to try to assure safe transportation and storage of the waste to and from and in these facilities. These programs include worker training, performance audits, regulatory information, and guidelines on safe transportation and handling. A number of products have been utilized to prevent transportation and storage accidents and to reduce damage when such incidents do occur. Examples of these products include:

- corrosion resistant linings that protect containers and vehicles from their contents
- gaskets that withstand chemical attack, thereby protecting joints and fittings against leaks
- chemicals foamed into placed at the scene of an incident that stop many tank, tank car, tank truck leaks

There has been quite a bit of publicity associated with transportation accidents involving hazardous materials used in the production of various consumer commodities. Almost all of these accidents are the result of trucking raw materials, some of which are fully as toxic as the worst of the hazardous wastes. It is necessary to continue to transport both hazardous raw materials and hazardous waste and both can be done with small risk.

The greatest strides in assuring the safety of people near an accident involving hazardous materials has been the improvement in information and response training.

In the case of an accident, the chemical industry has recently

established an around the clock emergency service to give immediate information to those on the scene of an accident. Response teams provide expert assistance when required. This service is called CHEMTREC. The U.S. Department of Transportation and the U.S. EPA cooperate with the system. CHEMTREC's emergency telephone number often accompanies shipments of hazardous materials and has been publicized to local and fire department and poison control centers across the country. CHEMTREC also runs training sessions for various emergency response groups.

VII. Costs

The costs for the various treatment facilities are summarized in the table on the following page.

The costs summarized for the proper disposal of hazardous waste are high. They become even higher when costs for transportation to distant out-of-state facilities are added. At present the New England states, in cluding Massachusetts, must depend upon service companies which utilize out-of-state facilities and this means Massachusetts industry pays more than its competition for waste disposal.

The unavailability of disposal facilities in the Commonwealth has been used to rationalize illegal dumping. But proper disposal service is available at a price. The reason behind illegal dumping is not "necessity" but avarice.

There are some people who believe that the cost of proper disposal is not worth it. This is because they do not understand or refuse to face up to the real costs of illegal dumping. Illegal dumping is a serious crime against persons. Our drinking water supplies can become contaminated. Frequently, we only discover the situation after a number of people become seriously ill. When the hazardous substances are identified, they are usually so widely dispersed in soil and water that clean up is impossible.

Thus, the expense of proper disposal of hazardous waste is negligible compared to the enormous cost of illegal dumping. Public education plus stiff enforcement of the law should make improper hazardous waste disposal a thing of the past. Certainly the legal structure is in place and penalties for illegal practices are specified with fines running up to millions of dollars and long prison terms. At the same time, the public is increasingly aware of their stake in preventing illegal dumping.

Construction of the type of facilities described in this chapter and a universal willingness on the part of hazardous waste generators to pay the full cost of proper disposal should be the wave of the future.

Costs for Hazardous Waste Disposal

Service/Treatment	Capital for Facility ($ millions)	Processing Cost ($/ton)
Recycling oils and solvents	1-15	minus 5¢-25¢/gallon
Detoxification of aqueous waste	3-6	50-100
Incineration	10-20	80-400
Solidification	3-10	10-100
Secure landfill	5-15	30-100
Transfer station	0.2-2	2-50

Chapter 3: The Legal Framework for Hazardous Waste Management in Massachusetts

Summary

Federal and state laws place strict controls on hazardous waste disposal to protect public health and the environment. Specifically, the U.S. Resource Conservation and Recovery Act (RCRA) and the EPA regulations implementing RCRA establish:

- a manifest system for tracking all hazardous wastes from "cradle to grave,"
- standards for handling and disposal of wastes by generators and permit systems
- a permit system for review and approval of all treatment, storage and disposal facilities.

These federal laws and regulations are supplemented by two state laws:

- the Massachusetts Hazardous Waste Management Act
- the Massachusetts Hazardous Waste Facilities Siting Act.

The first act is the state version of RCRA, although it is more stringent than the Federal program regarding transporter permit requirements, the use and siting of secure landfills, and financial responsibility. The Siting Act specifies a process by which environmentally sound facilities will be established. Integral to this process is the Siting Agreement, a set of conditions for construction and operation that is negotiated between the community and the developer. This agreement is a unique concept allowing for the protection of community interests during construction and operation of the facility.

I. Objectives of HWM Programs

The Federal Government and the Commonwealth of Massachusetts have established a network of laws to protect public health and the environment from exposure to hazardous wastes. Designed in the shadow of disasters like "Love Canal" and "Woburn," which resulted from faulty waste management practices of the past, the new laws mandate programs for strictly controlling hazardous waste from point of generation through transportation, storage, treatment and disposal. Having learned from the mistakes of the past, Federal and State governments are embarking upon a new era of regulation in which the risks of harm to health and environment from the handling of hazardous waste will be reduced to minimal, socially acceptable levels, without necessitating closure of industries that must produce such wastes in the course of providing necessities and amenities of modern life.

The overriding objective of the new regulatory programs is to insure that the public is not subjected to any greater risks from hazardous waste management than from other common industrial practices. Some of the regulations implementing these programs have already been issued by the Environmental Protection Agency (EPA). Additional regulations of both Federal and State agencies can be expected in the near future. The program will continue to evolve over the next several years, but it has already taken remarkable strides towards comprehensive control of hazardous wastes "from cradle to grave."

Achieving the full objective, however, will require more than stringent enforcement of management standards. Additional facilities are needed to safely treat, store and dispose of hazardous wastes that might otherwise be mismanaged. It is not possible to achieve a zero level of risk in operating such facilities, but they will be far safer than the alternative of building no new ones at all. To encourage their construction, the Massachusetts Legislature has enacted an innovative siting law, which affords meaningful roles to affected communities in determining the conditions on which HWM facilities may be sited, built and operated.

II. The Legal Framework

Subtitle C of the Resource Conservation and Recovery Act (RCRA) establishes the basic legal framework for both Federal and State HWM programs. Enacted in 1976, RCRA charges the Environmental Protection Agency with the duty of developing regulations for implementing the Federal Program and for transferring its administration to qualifying states with equivalent programs of their own.

In brief, Subtitle C authorizes EPA to issue regulations which:

- identify and list hazardous wastes
- establish standards applicable to generators and transporters of hazardous wastes and to owners and to operators of facilities that treat, store or dispose of such wastes
- develop a permit system for treatment, storage and disposal facilities
- authorize state HWM programs.

In addition, RCRA grants EPA broad inspection and enforcement powers.

On May 19, 1980, EPA published the first wave of Subtitle C regulations, which:

- identify hazardous wastes by specifying hazardous characteristics and by listing particular wastes as hazardous
- establish a manifest system for tracking every movement of hazardous waste from the point of generation to the point of treatment, storage or disposal
- establish an initial set of performance standards for treatment, storage and disposal facilities, and set the stage for the promulgation of further standards in 1980 and 1981.

RCRA encourages the states to take responsibility from the Federal government for controlling hazardous wastes within their borders, by establishing their own HWM programs. But a state program must meet with EPA's approval before it may be operated in place of the Federal program.

Authorization of state programs by EPA may proceed in two phases: (1) temporary interim authorization of state programs deemed "substantially equivalent" to the Federal program, and (2) final authorization of state programs deemed "at least equivalent to" and "consistent with" the Federal program. In the final analysis, EPA must determine that a state program is at least equal in effect to the Federal program before the former may supplant the latter. A state may choose to impose even more rigorous requirements on hazardous waste management than does the Federal government.

In 1979, Massachusetts passed its own Hazardous Waste Management Act, authorizing the Department of Environmental Quality Engineering (DEQE) to develop and implement a full fledged state program in this field. Looking forward to interim authorization of the state program in January, 1981,

the DEQE has:

- maintained in effect, for the time being, the 1973 regulations issued by the Hazardous Waste Board, and

- adopted verbatim the May 19, 1980 regulations issued by EPA.

The result is a state regulatory program that is, in some respects, more stringent than the Federal program administered by EPA.

DEQE will shortly publish a "Discussion Paper" setting forth key proposed regulations for the state's permanent program and identifying some issues that remain to be resolved in shaping it. When these regulations are finalized, they will control hazardous waste management at least as strictly-- if not more strictly than-- EPA's own program. The State's regulations are expected to win final EPA approval.

In 1980, Massachusetts also enacted a Hazardous Waste Facility Siting Act, which establishes a process for bringing together state agencies, developers, and representatives of communities in which developers may propose to locate HWM facilities. The culminating point in the process will be negotiation of siting agreements that set forth conditions acceptable to all concerned parties--host community, developer and state. The Siting Act preserves the regulatory independence of the DEQE, while making the Department of Environmental Management the proponent agency for new facilities.

Summarized above, the foregoing laws and regulations are the key measures for controlling hazardous waste in Massachusetts. They are not, however, the only relevant laws on this subject. Other protective laws remain in effect, including:

- the Clean Air Act, under which hazardous emissions to the atmosphere will increasingly be regulated;

- the Clean Water Act, under which EPA has been developing strict effluent standards and pretreatment standards for discharges of toxic effluents;

- the Safe Drinking Water Act, under which EPA has been developing standards for drinking water and standards for protecting underground sources of drinking water from subsurface disposal of wastes;

- the Federal Insecticide, Fungicide and Rodenticide Act, which controls distribution and application for toxic pesticides;

- the Toxic Substances Control Act, which provides a comprehensive framework for regulating all substances, whether wastes or not, that may pose unreasonable risks to health or environment;

- the Marine Protection, Research and Sanctuaries Act, which prohibits ocean dumping of wastes; and

- The Massachusetts Environmental Policy Act, under which proposed HWM facilities, as well as other major types of development, must be carefully assessed for control of adverse impacts before the developer can be allowed to proceed.

III. Resource Conservation and Recovery Act (RCRA)

As noted, Subtitle C of RCRA mandates a comprehensive Federal program for controlling hazardous wastes. Each section of Subtitle C sets forth a different element of the scheme. The May 19, 1980 regulations issued by EPA are designed to implement many of those elements, as described below.

Identification of Hazardous Waste

RCRA generally defines "hazardous waste" as a solid waste that may cause or significantly contribute to increased mortality or serious illness, or may pose substantial hazard to health or environment when improerly managed. ("Solid waste" is generally defined as garbage, refuse, sludge and other discarded material.) Those who generate wastes bear the primary responsibility under RCRA for determining which of their wastes are hazardous. Once a particular solid waste is categorized as hazardous, its handling is subject at all times and in all phases of disposition to the stringent controls of the RCRA program for hazardous waste management.

RCRA section 3001 requires EPA to develop and revise, from time to time, regulations that more specifically identify the characteristics of hazardous wastes and that list certain solid wastes as hazardous. If a solid waste exhibits one or more of those characteristics or is found on the list, it is deemed to be a hazardous waste for all regulatory purposes.

EPA has provided detailed specifications of the following four hazardous waste characteristics:

- ignitability: posing fire hazard

- corrosivity: ability to corrode standard containers

- reactivity: tendency to explode

- EP toxicity: the presence of certain toxic materials, as determined by a specific extraction procedure, at levels greater than those specified in the regulations.

Current EPA regulations also list nearly 500 wastes as hazardous, and the list continually grows longer. If any amount of a listed hazardous waste is mixed with nonhazardous solid waste, the entire mixture is deemed hazardous.

EPA's regulations currently allow some exemptions for small-quantity generators, so that EPA can initially concentrate its limited resources on the large generators. The Agency has indicated, however, that it will shrink the scope of such exemptions, and these need not be incorporated at all into a state's HWM program. Wastes that are reused or recycled, not including any listed hazardous waste that is being transported or stored, are also temporarily exempt from regulation under RCRA.

Notification

The Federal program was launched by regulations that required all persons who generate, transport, treat, store or dispose of hazardous wastes to notify EPA by August 18, 1980 of such activities. These notices consisted of reports identifying the subject wastes by listed numbers or hazardous characteristics, and the type of hazardous waste activity carried on at each reporting installation. The consequences of having failed to give the requisite notice by August 18 are severe: a prohibition against the further handling of hazardous waste by anyone who missed that deadline.

Every notifier was assigned an EPA identification number. This is an essential element of the program, which seeks to make identified persons responsible for each and every movement of hazardous waste.

Generators

RCRA section 3002 requires EPA to establish standards for generators of hazardous waste. A generator is one whose act or process produces such a waste. All persons who generate solid waste must determine which of their wastes if any, are hazardous. In order to make this determination, generators must familiarize themselves with the regulations specifying hazardous characteristics and listing particular wastes

as hazardous, and may have to test their wastes if there is any doubt about how they should be categorized.

The other major obligation imposed on generators is to initiate the manifest system for tracking the destiny of all hazardous wastes that leave their site of origin. A manifest is a shipping form containing specified information which must accompany every offsite movement of hazardous wastes. In general, the manifest system requires the generator to use only transporters who have obtained identification numbers, and to designate only a duly permitted treatment, storage or disposal facility to take delivery of the wastes.

The manifest itself must include:

- name and identification number of the generator
- name and identification number of of each transporter to be used
- name and identification number the designated receiving facility
- description of the waste(s)
- specification of the quantity of each hazardous waste in the shipment, and the number of containers on each transport vehicle
- certification that the waste has been properly described, packaged, and marked, and that it is in proper condition for transportation.

The generator must provide at least four copies of the manifest: one to keep for himself, one for each transporter, one for the designated facility, and one to be returned to the generator by the operator of the facility upon receipt of shipment. Each person who handles the shipment, including the generator, must sign and keep a copy of the manifest, and pass on the remaining copies to the next handler.

Receipt by the generator of a copy of the manifest, signed by the facility operator and by all transporters, signifies that the generator's shipment was handled according to regulation. If the generator does not receive such a copy in a timely fashion or in a properly executed manner, he must try to determine what went wrong. And if he fails to receive back an executed copy of the manifest after a certain length of time, he must submit an exception report describing the situation to EPA.

In addition to the duties associated with the manifest system, the generator must also:

- package the waste for transportation off-site in accordance with Department of Transportation regulations

- observe various recordkeeping requirements

- submit annual reports to EPA

- meet stringent requirements for temporary on-site storage of hazardous wastes before off-site shipping.

Transporters

RCRA section 3003 governs the transportation of hazardous wastes. A transporter is a person engaged in the offsite movement of such wastes by air, rail, highway or water. All transporters must obtain EPA identification numbers upon notifying EPA of their activities.

In part, EPA's regulations on transporters incorporate and require compliance with Department of Transportation (DOT) requirements on labeling, marking, placarding, use of proper containers, and reporting of discharges, all as promulgated by DOT under the Hazardous Materials Transportation Act. Other DOT regulations, not specifically incorporated by EPA, also remain operative. Thus, the transportation of hazardous wastes is controlled by two sets of Federal regulations.

In addition to observing DOT regulations, the transporter must comply with the RCRA manifest system. He may only accept hazardous wastes that are accompanied by a manifest signed by the generator. The transporter must keep the manifest with the shipment at all times. If one transporter delivers waste to another, the original transporter must sign the manifest and obtain the signature of the next, retaining one copy and passing along the others. A transporter who is unable to deliver to the facility designated on the manfest must contact the generator for further instructions and revise the manifest accordingly. The regulations forbid the transporter to redirect a shipment on his own.

All transporters are responsible for cleaning up any discharge of hazardous wastes that may occur during transportation. A discharge is the accidental or intentional spilling, leaking, pumping, emitting, emptying or dumping of hazardous wastes into the environment.

Facilities

Two sections of RCRA are devoted to the subject of facilities that treat, store or dispose of hazardous waste (TSD facilities). Section 3005 directs EPA to develop a permit system requiring that a separate permit be obtained for every such facility.

Section 3004 directs EPA to establish performance standards with which owners and operators of TSD facilities must comply.

The terms, "treatment," "storage" and "disposal" are defined in essence as follows:

- treatment includes any process designed to detoxify hazardous wastes
- storage includes the holding of hazardous wastes for a temporary period prior to treatment, disposal or shipment elsewhere
- disposal includes the discharge or deposit of a hazardous waste into or on any land or water, so that any constituent of such waste may enter the environment.

The Permit System

Any person owning or operating a TSD facility must obtain a general status permit in order to treat, store or dispose of hazardous wastes. The permit will tell the facility operator exactly how to comply with the law.

EPA has developed a two-part permit application. Part A must include:

- a specification of the facility's location, by longitude and latitude
- Photographs and scale drawings detailing past, present, and future TSD sites
- A list of hazardous wastes to be handled at the facility, estimated annual quantities of such wastes, and identification of the TSD processes to be employed.

An existing facility, i.e., one in existence on or before November 19, 1980, may have achieved interim status by (i) filing a notification with EPA by August 18, 1980, and (ii) submitting Part A of the permit application to EPA by November 19, 1980. Interim status means that the facility is temporarily considered as having been issued a permit and may lawfully operate if it complies with the Interim Status Standards (described below). However, a facility in interim status must eventually qualify for and receive a general status permit.

A TSD facility that is not in existence on November 19, 1980, or that otherwise fails to qualify for interim status, may not lawfully commence or continue operation until it actually receives a general status permit. The operation of permitted facilities must conform to the General Status Standards described below.

In order to obtain a general status permit, a TSD facility must

complete Part B of the permit application. This requires, among other things:

- a complete description of the facility
- chemical and physical analyses of hazardous wastes to be handled at the facility, and a waste analysis plan
- a description of all security procedures, general inspection procedures and contingency plans to be implemented at the facility.

EPA will need this information in order to establish that the applicant can meet certain General Status Standards. Not all of these standards have yet been established; the informational requirements of Part B will be amended to reflect additional standards as they are issued.

The procedures for issuing permits involve extensive opportunity for public participation. They include provisions for a public comment period during which interested parties may submit written comments to EPA on the permit application.

EPA may review a permit at any time to determine whether it should be modified or revoked. The agency may revoke a permit for failure of the applicant to disclose fully all relevant facts in the permit application, as well as for noncompliance with operating requirements.

Performance Standards

EPA has established two sets of operating standards for TSD facilities. The first are General Status Standards, which will serve as a basis for issuing site-specific permits. The second are Interim Status Standards, applicable to facilities that qualify for such status while awaiting their permits.

The regulations promulgated by EPA on May 19, 1980 establish many of the non-technical, General Status Standards, as well as the bulk of the Interim Status Standards. The former are known as Phase I, because they shortly will be supplemented by more technical Phase II standards. These will in turn be superseded by Phase III standards resolving complex technical issues and establishing detailed requirements for design, construction and operation of facilities.

Specifically, Phase I standards relate to administrative and non-technical aspects of operation, including requirements for waste analysis, security, inspection, personnel training, preparedness and prevention, contingency plans and emergency procedures, manifest system, record-keeping and reporting. Phase II standards, to be issued in the near future, will include technical and environmental performance criteria designed to guide EPA in issuing permits based on its "best engineering judgment" of the specific performance that individual facilities must achieve. Some of the most important Phase II standards for example, are those which EPA will impose on land disposal facilities in order to protect groundwater from contamination by hazardous wastes. EPA expects to implement a non-degradation standard, which presumes that any such contamination is unacceptable.

Other Phase II regulations will contain comprehensive requirements for the closure and post-closure phases of TSD facilities, as well as for financial responsibility in those phases. EPA has proposed regulations that would oblige owners or operators of facilities to establish trust funds or to obtain surety bonds or letters of credit, assuring that sufficient funds will be available for proper closure and postclosure care. These proposed regulations would also compel owners or operators to maintain certain levels of liability insurance.

EPA's Interim Status Standards, now in force for existing facilities that have permit applications pending, include administrative and non-technical operating requirements virtually identical to those mentioned above, as well as performance standards for particular types of TSD facilities, such as tanks, surface impoundments, waste piles, land treatment, landfills and incinerators. For example, certain facilities must have groundwater monitoring systems in place by November, 1981. The Interim Status regulations also require creation of written closure and postclosure plans, together with written estimates of the costs of closure and postclosure care.

In sum, EPA is well on the way to establishing comprehensive safeguards against the intentional or unintentional release of hazardous wastes to the environment at any phase of the management cycle. If this program is vigorously enforced--and there is every indication that it has top priority as a matter of federal and state policy--hazardous wastes will henceforth be managed so as to assure the health and safety of the public and the protection of environmental resources.

IV. Massachusetts Hazardous Waste Management Act

This law (the Massachusetts Act) is the state version of RCRA. It establishes a statewide program for safe management of hazardous waste. When the Department of Environmental Quality Engineering (DEQE) finally publishes its regulations to implement that program, it is expected to receive final EPA approval and accordingly to supplant the federal program summarized above.

The Massachusetts Act is more stringent than the federal program so far under RCRA, in at least these significant respects:

- it extends the RCRA permit requirements to <u>transporters</u> of hazardous waste
- it prohibits construction or operation of landfill disposal facilities on sites overlying <u>underground drinking water sources</u>
- it makes <u>landfill</u> a management technique of last resort
- it specifies financial responsibility requirements.

Most of EPA's regulations for implementing RCRA have also been adopted by the DEQE, including those defining hazardous wastes, prescribing the manifest system, and establishing requirements for TSD facilities. In addition, the 1973 regulations of the Massachusetts Hazardous Waste Board are still in effect. This combination gives the state a firm basis on which to start administering its own HWM program, with the expected interim approval of EPA.

The 1973 regulations go beyond EPA's in at least two respects. First, they make provision for the <u>licensing of hazardous waste transporters</u>. Secondly, they contain no exemption for small-quantity generators.

Early in 1981, DEQE will release a Discussion Paper suggesting the text or substance of key state regulations to replace the temporarily adopted federal ones. This paper is expected to generate discussion of a number of unresolved issues, including at what points, if any, the final Massachusetts regulations will be stricter or more far-reaching than those of EPA.

V. Massachusetts Hazardous Waste Facilities Siting Act

This law (the Siting Act) has no direct counterpart in federal law. Its objective is to facilitate the establishment of new, environmentally sound TSD facilities that will be acceptable to all concerned parties--

the state, the host community and the developer. Without such facilities, some industries located in Massachusetts will shortly face the dilemma of having no lawful means of managing their wastes, since little capacity remains available to them in facilities of other states.

The Siting Act seeks to accomplish its objective consistently with responsible municipal controls over land use, rather than by vesting preemptive siting power in any state agency. The Act operates in conjunction with other state and local laws, especially the Massachusetts Hazardous Waste Management and Environmental Policy Acts, to insure that the decision-making process for new TSD facilities will protect public health and the environment.

A key role in promoting implementation of the Siting Act has been vested in the Department of Environmental Management, which has issued a detailed explanation of the steps involved in the facility siting process. See the <u>Hazardous Waste Facility Siting Guide</u> issued by DEM in October, 1980. The highlights of that process will be briefly summarized below.

The Siting Act establishes a Hazardous Waste Facilities Site Safety Council. The council acts as an impartial overseer of the siting process, assuring equity in siting agreements to communities, facility developers and to the general public. The council provides technical assistance grants to host and abutting communities giving them the resources necessary for full participation in the siting process.

A developer starts the process by submitting a <u>Notice of Intent</u> to the state, to the host and abutting communities, and to the site owner. This notice describes the proposed facility and the wastes it would process. Proposals that clearly lack merit will be screened out by DEM.

The community creates a <u>Local Assessment Committee</u> that utilizes the technical assistance grant to analyze the proposed facility. The Act contemplates that the developer and the Local Assessment Committee will then proceed to negotiate a <u>Siting Agreement</u>, establishing the conditions under which the developer may build. There is a provision in the law for the arbitration of disputes that may arise during the negotiation process. There is no provision for state override of a Siting Agreement. However, the courts may strike down a capricious refusal to site a new facility.

The parties may negotiate conditions that go beyond the minimum siting and operating standards required

by law. They may, for example, agree upon details of design, construction, operation and monitoring; services and other benefits to be provided by the developer to the host community, and vice versa; provisions to assure protection of the environment and the health, safety, comfort and security of the host community and its citizens; guarantees of financial responsibility and economic viability; and methods for quick resolution of disagreements that may arise during the life of the facility. No new TSD facility can be established in this state without a siting agreement. Its terms are to be negotiated, but in the event of an impasse, they may be determined by independent arbitration.

Moreover, no site may be used for a TSD facility unless the Board of Health of the host community has assigned the site for that purpose after a public hearing. Any assignment may be subject to such conditions as will assure that the facility poses no significantly greater dangers to the public than other current industrial activities.

Establishment of a TSD facility may also require a special permit from a municipal zoning board (under an ordinance that was not changed for the purpose of excluding the facility after the developer filed his notice of intent), and an order of conditions from the local conservation commission where the Wetlands Protection Act applies. In all these ways, the Siting Act preserves the rights of municipalities to exercise responsibly their traditional powers over local land usage and development.

Finally, a TSD facility must obtain a permit from DEQE under the Massachusetts Hazardous Waste Management Act and implementing regulations. As noted, these will be at least as rigorous as EPA's regulations on construction, operation, closure, post-closure care, and financial responsibility.

The combination of regulatory and siting laws, summarized above, shows promise of working in this state to achieve the dual objectives of hazardous waste management: to provide needed TSD facilities, and to assure that their operation will pose no unacceptable risks to human health and environment.

Chapter 4: Protecting the Community

Summary

Hazardous waste facilities are needed to protect public health and welfare in the Commonwealth. Without sound facilities, there will continue to be great risks of health hazards from illegal disposal -- and risks of economic disruption as manufacturing plants are moved nearer to proper facilities. While protection of public health is the reason for new facilities, public health concerns are also the reason that some people are worried about the localized impacts of the facilities. Chapter 3 describes the laws and enforcement mechanisms through which the state and federal governments protect public health.

This chapter discusses the equally important steps that communities can take to protect themselves. The first two sections of the chapter briefly introduce the role of negotiations in the siting process. The chapter then presents a hypothetical situation in which a community and a developer explore ways to resolve their transportation concerns. This example illustrates the types of measures which can be identified through negotiations to protect public health.

I. Negotiations Identify Ways to Protect Your Interests

There are three reasons why countries and developers can expect negotiations to help them protect their respective interests. Most obviously, leaving decisions up to others is no way for anyone to protect their interests. Second, experience with negotiations shows that serious negotiators can find protective measures that can reduce risks and adverse impacts to acceptable levels. Finally, appropriate ways can often be found through negotiations to compensate the community for the costs it still bears after all realistic protective measures have been agreed on.

Some people fear that through negotiation they may bargain away something for which there is no acceptable compromise. However, there may be a greater risk by leaving decisions up to developers, governmental agencies, arbitrators, or courts. By getting constructively involved in negotiations, communities no longer have to rely on government regulators to protect them. This is

the unique feature of the Massachusetts siting law -- it respects the right of a community to protect itself by participating directly in the decision process. During these negotiations the community will have the necessary technical, legal, and financial expertise available through consultants supplied by the Department of Environmental Management or hired by the community at state expense.

The most important way that negotiations help all participants to protect their interests is by identifying protective mechanisms. In fact, it is often possible to find "win/win" solutions that meet the important objectives of everyone involved. The example in this chapter of negotiations resolving a siting conflict suggests some mechanisms and solutions of this kind. Other examples of protective mechanisms that may serve as good starting points for these exploratory or "problem-solving" negotiations are provided in section IV at the end of this chapter.

Finally, negotiations can protect a community's interests by identifying ways to compensate the community for costs it may incur by providing the site for a facility to meet this important public need. The Massachusetts law explicitly provides a host community with the opportunity to negotiate with developers about services and benefits such as those discussed in section III of this chapter.

II. Negotiations Can Be Manageable

Some communities and developers may perceive negotiations as too time-consuming, complex or expensive to get involved in. However, the Massachusetts Siting Law and the state bodies that carry out that law can make several forms of assistance available to help all parties use the negotiation process to protect their interests.

The Massachusetts Department of Environmental Management (DEM) is the primary source of such assistance, on behalf of the Site Safety Council. Through DEM and the Council, citizens can obtain help in locating technical publications or specialists. In addition, grants of funds are available for communities to hire technical experts to assist them directly. These grants are available in amounts of $15,000 per municipality, plus additional amounts if approved by the Council. Adjacent communities could also pool these funds to expand the scope of technical studies they can perform.

The Siting Act also authorizes DEQE to provide technical assistance to municipal Boards of Health during

the site assignment process. Other sources of potential assistance include the Massachusetts Department of Communities and Development, and the Regional Planning Agencies.

The Site Safety Council is also required by the Siting Act "to advise all participants in the (siting) process as to methods and actions designed to provide for the more effective, efficient and successful implementation" of the process, and "to encourage and facilitate negotiations." The Council and the Department of Environmental Management are currently preparing a Siting Manual which will assist communities and developers in getting started and carrying out negotiations, as well as describing the Council's regulations.

In addition, a number of handbooks, pamphlets and papers have been written to introduce the layman to negotiations to resolve complex environmental and technical disputes. The New England Regional Commission (NERCOM) has recently issued a series of Handbooks for Siting Acceptable Hazardous Waste Facilities in New England. One of these Handbooks, entitled Negotiating to Protect Your Interests, describes several critical components of successful negotiations, uses case studies to illustrate what can be negotiated, and discusses the general rationale for negotiation and compensation in the hazardous waste facility siting process. Other Handbooks in this NERCOM series include a Decision Guide (which suggests technical and procedural questions that each participant might want to consider at the orientation, scoping, consultation, problem-solving and negotiation phases of the siting process) and a booklet entitled Criteria for Evaluating Sites.

After an agreement is reached between community and developer negotiators, a legally binding contract called a "Siting Agreement" is formalized, which can then be enforced through the courts by the municipality. The DEQE could, in addition, incorporate some or all of the environmental components of this agreement into its permit for the facility, which would enable the state to monitor and enforce those portions of the agreement as well, as part of its regulatory responsibilities.

Finally, the negotiation process need not be a drawn-out, time-consuming one. The developer is required to prepare an impact report describing the environmental and social economic impacts of the project, with review by the Siting Council and the Secretary of Environmental Affairs (through the MEPA unit, under the Massachusetts Environmental Protection Act). The negotiators will be able to use the preliminary draft of this report

as a basis for negotiation. Furthermore, the Siting Council may, two months after state acceptance of the draft impact report, determine that an impasse exists and arrange for impartial arbitrators to establish a binding Siting Agreement within 45 days. Experience with negotiations indicates that the existence of deadlines and the potential for arbitration tends to encourage parties to find ways to reach their own voluntary agreement promptly. Overall, it is estimated that the procedural requirements of the Siting Act, including the required negotiation process, will add only a few months to the total approval/construction period.

III. Types of Protective Mechanisms and Benefits

Consider yourself a resident in a hypothetical community in which a developer has recently proposed to build a new hazardous waste management facility with several different processes to handle a variety of wastes. This developer then describes his proposal. His preliminary project impact report indicates that, on an average operating day (Monday through Saturday), four railcars would arrive at the proposed facility with wastes in bulk, and 20 tanker-trailer trucks would leave the interstate highway and travel on two miles of local two-lane roads to the facility. Only two to three of the departing trucks would carry any wastes, on their way to a secure landfill in another community.

Next, instead of saying to the community "take it or leave it," the developer says: "Let's talk about this proposal and see what changes might be made in it to address your concerns." Likewise, the community, instead of immediately saying "NO!" to the developer, says: "Well, let's at the least find out what this proposal is really all about and perhaps how we might benefit from it." So negotiations begin.

Variables to Consider

The transportation problem is itself full of creative opportunities for problem-solving. What is needed is goodwill among all affected parties to pool their ideas, research options and negotiate a resolution. Thus, the parties can start by listing all the factors or variables that must be considered:

- Types of waste materials (degree of toxicity, reaction in the environment)
- Planned routes, and for each: types of street traffic, road width, historical frequency of accidents; residential or other sensitive sites along routes;

special up-grading or road maintenance needed

- Frequency of trips
- Length of trip - long haul versus short haul
- Size of load (few large shipments, lots of small ones)
- Mix of truck, rail, other modes
- Mix of bulk shipments and drums
- Types of hauling equipment - hoists, fork lift, pallets, type of barrels, storage tanker, labelling, tank cars
- Use of pipelines
- Ownership of vehicles by facility operator (or other single entity) or by multiple delivery firms
- Types of manifests and controls
- Potential impacts (health, safety, environmental, noise, economic, other)
- Costs of alternative transportation plans.

Types of Outcomes

It is important for all parties in a negotiation process to open their thinking to a full range of variables such as this. Nevertheless, everyone's primary concern is always with outcomes. At the outset, when a community representative first starts to think about transportation risks the following simple outcomes might come to mind:

My win - No trucks on streets where I or my family might go

My lose - High risk trucks on streets where I or my family might go

A facility developer might view transportation outcomes this way:

My win - No special restrictions on delivery of wastes to facility

My lose - Added costs and possible schedule disruption from special restrictions on deliveries

Both communities and developers can move beyond these "all or nothing" outcomes, however, by taking a hard look at the expanded list of variables and beginning to look for new ways to protect their most important interests.

To start exploring new outcomes, the first step is usually to anticipate, avoid or manage particular impacts through protective mechanisms. Then, if some costs remain to be borne by the community, benefits can be explored to compensate for these costs. These two types of negotiable items are discussed in the next two sections.

Protective Mechanisms

After sustained negotiations over variables such as those listed above, parties might identify -- and eventually reach agreement on -- some of the following potential solutions to reduce risks and impacts on the community (in addition to required measures discussed in Chapters 2 and 3):

- Enforceable restrictions on routes to be used
- Requirements for particular mode (e.g., rail), route, or procedures for particular materials
- Concentration or partial treatment of waste at source or at transfer stations, to reduce frequency of trips or toxicity of waste
- Compromise arrangement with no route restrictions but with lower-risk materials or segregated traffic
- Special access road construction
- New commercial trucking route to avoid residential or other areas of concern
- One-way traffic on certain routes, using special new lanes, or selected hours
- Delivery hours restricted to when few people in transit
- Accident prevention requirements -- for example, no driving on wet, snowy or icy highways (enforced pull over or insurance restrictions)
- Relocation of playgrounds or other sensitive facilities to locations more removed from waste transportion routes

- Requirement for periodic checks for leaks, fumes, etc.; en route, at check point

- Licensed drivers -- special training in case of accidents, etc.

- Use of escort vehicles for trucks in key areas or with particular wastes

- Transfer depot delivery to facility via pipeline, and/or special shuttle carrier

- Use of trucks or other vehicles specially designed or equipped to minimize noise

- Arrangements to permit authorized community representatives to monitor vehicle inspection procedures, or to participate in future decisions about transportation

- Clear authority and procedures for evacuation, clean-up and other health-related decision-making in the event of an emergency.

Benefits

Many of these potential outcomes include protective mechanisms -- they help protect the community by reducing risks or impacts. But "what's in it for the community" or for abutters from development of a facility? In some cases the facility may keep a nearby generator from moving away. If this is true, these saved jobs may represent a localized benefit that compensates the community for the localized costs. Without some such local economic gain, however, a community may not feel that a facility is in its interests, even though the economic and environmental benefits to the state as a whole are substantial. As a result, after agreement on measures to reduce impacts, it may still be necessary to compensate the community for accepting its disproportionate share of the remaining impacts associated with the proposed facility. For example, negotiators might identify such potential outcomes as these:

- Direct payment for municipal costs required for upgrading of public roads

- Arrangements for annual payments in addition to conventional municipal taxes, to cover anticipated cost increases in fire, public works, or public safety departments

- Provision of transportation-related services, by the facility operator or by the state, such as snow plowing or safe storage of road salt

- Establishment of a trust fund -- with specified contributions by the developers, and/or by generators contracting for treatment capacity -- to guarantee property values along specified transportation routes

- Provision of land, funds, or technical assistance or other services to help the community develop a recreational, cultural, or other valued facility, to offset unquantifiable costs associated with hosting a facility regarded as inconsistent with community character or plans

Each of these potential solutions goes part way toward meeting community needs and part way toward meeting developer needs. No one can say in advance what outcome will be appropriate or realistic for any particular situation. The cost of the agreement must, of course, be realistic for the facility operator and/or the Commonwealth to bear -- it would probably be neither cost-effective nor necessary to agree on every possible measure.

The negotiators will seek out the solutions which they feel will best meet their needs while at the same time meeting enough of the needs of other parties to make an agreement possible.

Negotiations Are Nothing New

Negotiations such as these have always taken place on an ad-hoc and often informal basis in cities and towns throughout the Commonwealth. Negotiations have been undertaken from modest landscaping proposals or small shopping centers to large-scale public facilities such as mental health institutions, prisons, airports, energy facilities as well as hazardous waste management facilities.

For example, whenever a developer proposes a subdivision, new office building or industrial plant in a Massachusetts town, informal negotiations occur between the developer and town representatives (local boards, elected officials, abutters, and citizen groups). Local planning involves numerous trade offs between the developer and local boards. Perhaps an office building is so large that it must be redesigned to be consistent with the scale of its surroundings. Maybe the land-use change is drastic (such as putting an industrial park next to a scenic or residential area) so that town

leaders request an offsetting amenity from the developer to compensate for altering the character of the community. Perhaps a proposed subdivision will over-populate existing schools so that town leaders request an offsetting amenity from the developer.

IV. Other Types of Benefits and Protective Mechanisms

Transportation is, of course, only one area of concern to communities and developers. In this section we list some of the measures which negotiators may want to consider in the additional areas of concern, including economic impacts, contamination of ground and surface water and air pollution. The reader is also referred to the NERCOM handbook mentioned in Section II above, entitled "Negotiating to Protect Your Interests."

Transportation Impacts

- Transportation re-routing
- Access road construction
- Relocation of playgrounds or other sensitive facilities
- Payment for increased road maintenance or reconstruction
- Limitations on hours for delivery
- Muffler installation

Economic Impacts

- Municipal gross receipts taxes
- Tipping fees for municipal revenues
- Prepayment of property taxes
- Direct payments to neighbors for diminished property values
- Land-value guarantees (or other conditional payments)
- Payments for increased equipment or personnel costs to be incurred by local fire, police, or public works departments
- Free disposal for local industry

Groundwater Contamination

- Leachate monitoring, collection and withdrawal systems
- Clay and synthetic liners: extra thickness, multiple liners

- Spill prevention and containment measures
- Groundwater monitoring systems at site and in potentially affected areas
- Subsurface "slurry wall" barriers
- Controls on other groundwater withdrawals in area
- Additional preconstruction soil borings and groundwater modeling
- Special "environmental impairment" insurance beyond RCRA requirements (see Chapter 3)

Surface Water Contamination

- Special collection and treatment systems for surface runoff
- Provision of alternate water supply system
- Flood control dikes
- Oversized or redundant capacity for hazardous wastewater treatment facilities
- Monitoring and automatic shutdown systems for any effluent discharged to rivers

Air Pollution

- Additional, oversized, or redundant pollution control equipment
- Special combustion monitoring and automatic shutdown systems
- Increased stack height for incinerators
- Special air monitoring arrangements

General Concerns

- Financial responsibility arrangements beyond those required under RCRA -- e.g., additional trust fund resources or provisions (see Chapter 3)
- Procedures for quickly settling disputes after permitting so that the developer is not subjected to repeated harassment, nor the community to time-consuming proceedings before relief
- Role for public agency or representatives in monitoring facility operations and performance data, and/or operation and management
- Provision of or financial contribution for park or conservation land, recreational facilities, health clinics, schools

- Provision of funds to support impact or planning studies

- Limitations on facility operating hours

- Evacuation plans

- Clean up of spills or discovered hazards unrelated to facility operations

- Consent decree or other binding agreement to shut down facility if specified unsafe conditions occur in future

- First-aid training related to chemical wastes for public safety officials and the public

- Other special facility design features

In conclusion, the range of possible benefits and protective measures is so broad that it should be possible for serious negotiators to develop a sound Siting Agreement that protects the interests of all parties.

Chapter 5: The Current Situation in Massachusetts

Summary

There are no accurate reports on hazardous waste generation in the Commonwealth. Based on studies now two years old, there are 250,000 to 400,000 tons/year to be treated or disposed of off-site of the generating plant. The breakdown of this waste by type is presented in Table 5.1.

Nine facilities exist for hazardous waste treatment, handling principally oils, solvents and aqueous waste. Only two are of substantial size. Their total capacity per each waste type is detailed in Table 5.4.

Comparisons of hazardous waste generation and treatment capacity show that additional capacity is required as follows. This takes into account future trends and total New England capacity as discussed in this chapter.

Waste Exchange	- should list all hazardous wastes
Oil Recovery	- none, sufficient capacity in New England
Solvent Recovery	- ca. 10,000 tons/year for flammable solvents
Aqueous Treatment	- up to 40,000 tons/year, decisions made about pretreatment will control
Liquid Incineration	- ca. 25,000 tons/year
Rotary Kiln	- 25-50,000 tons/year
Secure Landfill	- at least one

I. Sources and Quantities of Hazardous Wastes

Data Base. A major problem with reporting the amounts of hazardous wastes produced in Massachusetts is the absence of any comprehensive waste inventory.

Even the existing studies -- one by Arthur D. Little, Inc. for the New England Regional Commission and the other by GCA Corporation for the Massachusetts Division of Water Pollution Control -- have serious limitations

with respect to their methodologies and age of data. Both studies are based on a 1976 survey of firms, not necessarily representative, performed by GCA. Using that survey, GCA estimated industry-wide generation and ADL estimated waste-specific generation. The extrapolations upon which those studies are based assume that for every percentage increase in employment an equal percentage increase in hazardous waste quantity occurs. This relationship may not be altogether accurate. Source reduction, recycling, and other changes to manufacturing processes may reduce hazardous waste generation without a corresponding reduction in employment. Similarly, additional employees may be added to a firm without an increase in the amount of hazardous waste produced.

Despite the limitations in the existing data, the MERCOM and Division of Water Pollution Control reports provide a general picture of waste generation in Massachusetts. A Briefing Document, recently prepared for the Massachusetts Department of Environmental Quality Engineering by TRC Environmental Consultants used the earlier studies' figures to indicate general trends in hazardous waste generation. In this report, too, the figures are not to be taken as precise values. Information available in the near future from the regional manifest system, the MDC pretreatment program, and monthly reports filed by generators may improve the measurements of hazardous waste generation for subsequent EIRs.

Quantity of Waste. The NERCOM study presented state-by-state estimates of hazardous waste generation in New England. These estimates are given in Table 5.1. Only the Massachusetts figures are presented on the following page.

Changing industry processes, caused by rising treatment/disposal costs and petroleum prices, and the implementation of new public policies, are expected to alter the picture presented by Table 5.1. The Metropolitan District Commission's new wastewater pretreatment program will generate additional volumes of sludge as toxic constituents of industrial wastewater

Table 5.1: ESTIMATED QUANTITIES OF WASTE GENERATED IN MASSACHUSETTS AND DISPOSED OF OFF-SITE*

Waste Type	Thousand Tons/Yr.
Automotive Oils	55
Industrial Oils	46
Solvents	32
Acids/Alkalis	24
Sludges	77-220
Chemicals	13
Other	4
Total	250-400

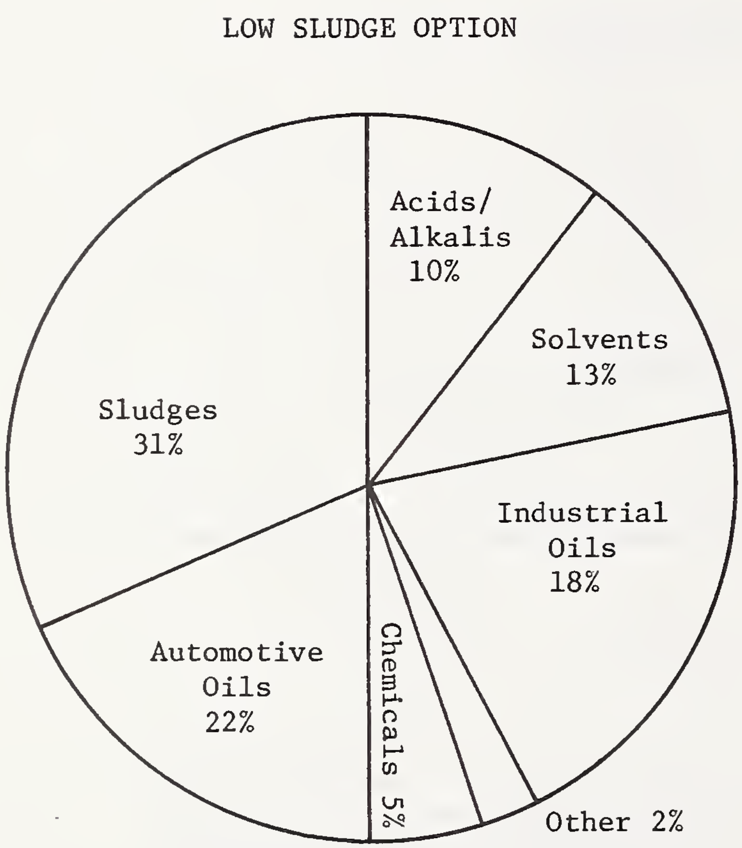
Source: New England Regional Commission, A Plan for Development of Hazardous Waste Management Facilities in the New England Region, prepared by Arthur D. Little, Inc.

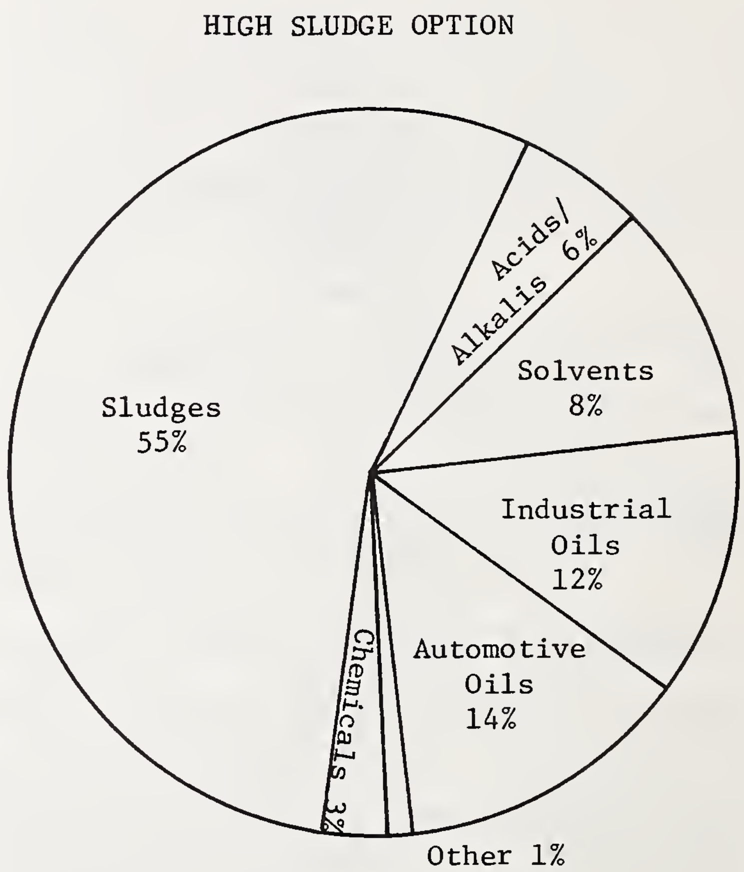
Conversions to tons based on 1 ton = 250 gallons = 1 cubic yard.

Sum of column does not equal total due to rounding.

*The quantities were extrapolated from best available State inventory data, as described in Appendix B (referenced report). The numbers given include only wastes defined as hazardous under the Federal RCRA regulations proposed on December 18, 1978, and only those defined hazardous wastes not currently being properly handled on-site. The following wastes were excluded from this tabulation: (1) wastes recycled on-site; (2) wastes discharged to sewers; (3) paper mill sludge; (4) wastes sent to lagoons as part of an in-plant water treatment system; (5) fly ash scrubber sludge. See discussion on wastewater treatment sludges (p. 5-8) for an explanation of the ranges of values under sludges.

BREAKDOWN OF MASSACHUSETTS-GENERATED HAZARDOUS WASTE BY TYPE*





Note: Percentages do not total 100 due to rounding.

*Based on New England Regional Commission, A Plan for the Development of Hazardous Waste Facilities in the New England Region, prepared by Arthur D. Little, Inc.

are removed from discharge waters. The NERCOM report indicates that 50-150,000 tons of sludge per year might be generated from wastewater treatment programs. Various pretreatment technologies exist, however, and each influences the quantity of sludge generated differently.

A reduction in the demand for off-site solvent disposal is probable, given increasing petroleum costs and the consequent increase in the value of solvents as a fuel substitute.

Industry, reacting to higher treatment/disposal and energy costs can be expected to improve process efficiencies. This should cut waste generation at the source. A successful effort to reduce off-site waste treatment demand is illustrated by the experience of the Danish national waste treatment facility, Kummenkemi. In the inorganic waste category, 54,000 tons of waste were expected last year, only 7,000 tons were received. In Massachusetts, some companies have pledged to reduce the wastes at source by 80 percent over the next five years.

The NERCOM report does not provide a distribution of the waste by industry; for this information the Division of Water Pollution Control report can be used. GCA considers the estimates in that report as lower limits accurate to within a factor or two.

Hazardous wastes in Massachusetts are primarily generated by 15 general industrial categories. A distribution of wastes among more specific categories can be found in Appendix A of the Division of Water Pollution Control report.

Table 5.2 shows industry-specific waste generation in Massachusetts. For an introductory discussion of the processes in each of these industries that generate specific hazardous wastes, the reader should see the Division of Water Pollution Control report.

GCA's survey of hazardous waste generation in Massachusetts prepared for the Division reveals an interesting distribution of waste types from various sources. It was found that the fabricated metal products and non-electrical machinery industries account for over 55 percent of the industrial waste oils generated in Massachusetts.

Solvents are used primarily by the electronics industry and by miscellaneous industries such as jewelry and silverware manufacturers. Approximately 41 percent of the state's total solvent waste is generated by these two industries.

Metal sludges and plating wastes were found to be mainly produced by foundries, fabricated metal products, and non-electrical machinery industries. The combined waste from

Table 5.2: THE DISTRIBUTION OF MASSACHUSETTS-GENERATED HAZARDOUS WASTES AMONG VARIOUS INDUSTRIAL CATEGORIES (tons per year)

		WASTE TYPES**							
	%	Oil	Solvent	Plating Waste and Metal Sludge	Misc. Sludges	Acids/ Alkalis	Other Hzd. Wastes	Totals
Textile mill products (dyeing and finishing only) (22)	1	9	1,131	2	--	--	--	1,142
Paper and allied products (26)	1	82	639	--	--	--	14	735
Printing, publishing and allied industries (27)	1	140	498	--	--	169	72	879
Chemicals and allied products(28)	27	206	228	unknown	20,286	334	1,780	22,834
Petroleum refining and related industries (29)	12	2	--	--	9,832	--	115	9,949
Rubber and miscellaneous products (30)	2	1,662	414	--	6	--	2	2,084
Leather and leather products (31)	5	1	297	2,923	1,234	--	--	4,455
Stone, clay, glass, concrete products (32)	--	--	--	--	--	--	unknown	unknown
Primary metals industries (33) Foundries	14	357	53	4,265	186	7,297	--	12,158
Fabricated metal products except machinery(34)	10	2,755	965	4,006	73	191	365	8,355
Machinery except electrical(35)	10	3,634	122	3,210	334	1,063	--	8,363
Electrical and electronic machinery(36)	6	1,265	2,010	1,317	5	117	326	3,040
Transportation equipment(37)	2	811	19	--	537	--	--	1,367
Measuring, analyzing, and controlling instruments: photographic, medical and optical goods, watches and clocks(38)	7	562	3,292	320	1,291	--	348	5,813
Miscellaneous manufacturing industries	2	88	1,360	98	9	--	--	1,555
Total		11,574*	11,028	16,141	33,793	9,171	3,022	84,729

Source: Massachusetts Division of Water Pollution Control, The Generation and Disposal of Hazardous Wastes in Massachusetts, prepared by GCA Corporation, October 1976.

Figures from referenced report converted to tons (1 ton = 250 gallons).

See Appendix for explanation of waste types.

*Oil column does not include approximately 61,740 tons of automotive oil nor approximately 12,000 tons of oil from small generators and miscellaneous non-industrial sources

these classes is approximately 71 percent of the total metal sludge and plating waste in Massachusetts.

Foundries and smelting operations generate approximately 80 percent of the state's acid and alkali waste in cleaning processes.

The chemical industry accounts for 60 percent of the miscellaneous organic and inorganic sludges generated in the Commonwealth. Paper, printing and textile industries generate large amounts of non-hazardous wastes.

"Other Hazardous Wastes," as used by GCA, includes undefined or unknown wastes reported during the survey, as well as wastes that are not classified under the other five waste types. Close to 60 percent of these wastes come from the chemical industry. Fabricated metals, electrical equipment and miscellaneous manufacturing industries combined produce 34 percent of the unclassified wastes such as photographic chemicals, resins, inks, and polymer solutions. Waste inks from the paper and printing industries comprise most of the remaining other hazardous wastes.

Other Sources of Hazardous Waste. The GCA survey did not contact firms involved in food, clothing, wood and furniture or stone, clay, glass and concrete products because it was assumed that these industries generate very small quantities of hazardous waste. Small quantities of waste oil, some waste solvent and other organic chemicals from wood and furniture manufacture plus caustics from food processors may be produced by the approximately 2,500 plants in Massachusetts that were excluded from the survey. According to the GCA report, if each of these plants produced one drum of waste oil per year, the estimate of industrial waste oil would increase by 26 percent or 3,000,000 gallons (12,000 tons).

Hospital Wastes - Nonpathogenic hazardous wastes from hospitals include waste chemicals, solvents and oil. Based on there being 163 hospitals in the Commonwealth, an estimated 144 tons of waste chemicals and solvents and 18,000 gallons (72 tons) of waste oil were said to be generated annually by hospital sources.

Waste Automotive Oil - According to a 1969 Division of Water Pollution Control report, "Study of Waste Oil Disposal Practices in Massachusetts," 66 percent of all automotive oil sold within the Commonwealth ended up as waste oil. GCA updated that report and estimated that 15,435,000 gallons (61,740 tons) of waste oil were generated in 1975. Adding this figure to the industrial and "other" waste oils gives an approximate total of 85,000 tons of all waste oils per year.

Polychlorinated Biphenyls - PCB's have not been manufactured in the United States since 1979. However, transformers and capacitators made before the PCB ban are still in use and, as they are replaced with newer equipment, must be disposed of as a hazardous waste. GCA estimated that 120 tons of waste PCB's were generated in Massachusetts in 1975.

Pesticides - Pesticide use in Massachusetts generates hazardous waste primarily from empty containers which still have pesticide residue. There are no pesticide manufacturers or formulators in the Commonwealth. GCA estimated that the annual quantities of empty pesticide containers at 25,500 5-gallon cans and 800 55-gallon drums, or 26,300 empty pesticide containers annually. Approximately one thousand times the amount of contained waste pesticides is applied to crops, gardens and rights of way in the Commonwealth. The volume of waste pesticides is small in comparison to the amount of pesticides used as a farming and gardening tool.

Wastewater Treatment Sludges - Implementation of pretreatment standards by the Metropolitan District Commission and Municipalities will require more industries to put in wastewater treatment facilities. This will add to present quantities of industrial sludge being generated.

Industries listed in Table 5.3 whose wastewater characteristics exceed discharge standards are required to have operational pretreatment facilities within three years of the publication of standards by EPA (standards are scheduled to be promulgated over a period of time extending through July 1981).

A firm's decision of which pretreatment method to use is based on economic and technological factors. Although different pretreatment technologies will produce different volumes of sludges, the NERCOM report indicates that about 50-150 additional tons of sludge can be generated by the pretreatment program. It is probable that most of the 1,000 firms expected to require pretreatment will generate heavy metal laden sludges. After MDC's program is in its more advanced stages, more specific information on industries, technologies, sludge types and volumes will be available.

II. Existing Facilities

This section will present the capacities and processes of licensed hazardous waste facilities. The information was compiled from existing sources plus, whenever possible, short telephone checkups. More information will be available for the 1982 EIR from the new state manifest system and monthly reports filed by facilities to the

Table 5.3: EPA INDUSTRIAL CATEGORIES FOUND IN MASSACHUSETTS SUBJECT TO PRETREATMENT STANDARDS*

Adhesives	Gum and Wood Chemicals
Leather Tanning and Finishing	Paint and Ink
Soaps and Detergents	Printing and Publishing
Aluminum Forming	Pulp and Paper
Battery Manufacturing	Textile Mills
Coil Coating	Timber
Copper Forming	Steam Electric
Electroplating	Plastic and Synthetic Materials
Iron and Steel	Rubber
Nonferrous	Automatic and Other Laundries
Photographic Supplies	Mechanical Products
Plastics Processing	Electric and Electronic Components
Porcelain Enamel	Inorganic Chemicals

*The listed categories are those for which EPA will issue pretreatment standards, according to federal publications as of early 1980. The actual date when such standards will be issued is uncertain; information from EPA officials indicates that the standards will appear over a period of time extending through July of 1981.

Division of Hazardous Waste.

Nine Massachusetts firms are operating and licensed by the Massachusetts Division of Hazardous Waste to operate treatment/disposal facilities for waste generated by other firms. This does not include the seven facilities that only process their own hazardous waste. All nine accept hydrocarbon liquids (motor and industrial oil, some organics, solvents, lacquers) while two major facilities also accept aqueous inorganics, cyanide and plating wastes, solids and sludges of every kind, and pesticides in addition to the other wastes.

Table 5.4 lists the wastes accepted by the two major facilities, their processes, and capacities. Both are operating at maximum capacity. Below Table 5.4 is a list of the eight smaller facilities in the state. In some places there are blanks on the Tables. Contacts were unavailable or unable to provide data in some instances.

In addition to the nine facilities that accept wastes from various generators, seven facilities have licenses limiting their sources of wastes. These private companies have chosen for technical, economic, regulatory and/or management reasons, to only accept wastes from the sources specified below. Most facilites indicated in Table 5.5 are operated by generators themselves to handle only "in-house" wastes:

Table 5.4: NINE LICENSED AND OPERATING HAZARDOUS WASTE FACILITIES IN MASSACHUSETTS

A. Major Facilities

Facility/Location	Wastes	Processes	Capacity
Lewis Chemical Company Hyde Park	Solvents	Solvent Recovery	20,000 tons/year
Recycling Industries Braintree	Industrial oils solvents, organic chemicals, (hydrocarbon liquids), all aqueous liquids	Solvent Recovery	20,000 tons/year
		Liquid Incineration	4,500 tons/year
		Sludge Dewatering	16,000 tons/year
		Solids Incineration	1,800 tons/year
		Wastewater treatment and pretreatment consolidation	80,000 tons/year

B. Smaller Facilities

Facility/Location	Wastes	Processes	Capacity
Eastern Chemical Specialties, Inc. Worcester	Solvents	Solvents Reclamation	96 tons/year
Geochem, Inc. Lowell	Solvents	Solvent Recovery	900 tons/year

Smaller facilities continued:

Facility/Location	Wastes	Processes	Capacity
Trombetta, Inc. Marlboro	Industrial oils Solvents	Oil used to heat greenhouses, solvents used to thin oils	1,600-2,000 tons/year (90% is oil)
Mayflower Salvage Co., Inc. Taunton	Industrial oils		
Stiles and Hart Brick Co. Bridgewater	Motor and industrial oils	Process heat	unknown - is converting to coal
Roberts Motor Sales, Attleboro	Motor oils	Burned for space heating	unknown - 20 tons storage
Ted Ondrick Construction Co. Chicopee	Motor oils	Burned as process fuel in asphalt plant	72 tons/year

Table 5.5: ON-SITE TREATMENT/DISPOSAL FACILITIES

Facility/Location	Wastes	Process	Excess Capacity
New England Power Co. Westboro	Power plant waste-water treatment sludge (stabilized metallic sludge)	Secure landfill	None
Sprague Electric Co. North Adams	Solid Chemical Compounds, clay and filter media, oily solids		
ICI Americas Dighton	Clay and filter media	Secure landfill	2100-2800 tons (approximately 15-20 years at current generation)
American Optical Corp. Southbridge	Solvents	Incineration	Cannot define
Greater Lawrence Sanitation District (facility/Western Electric Company (generator)	Stabilized metal	Neutralization by mixing with waste ash, then secure landfill	None
General Electric Co. Lynn	Motor and industrial oils, solvents, all aqueous liquids		
General Electric Co. Pittsfield	All hydrocarbon liquids, all aqueous liquids, solid chemical compounds, oily solids, PCBs (up to 500 ppm)		

Hazardous waste management costs rise with increasing distances to hazardous waste facilities. In fact, transportation costs account for a major portion of the total cost of waste disposal. Massachusetts generators therefore, seek the closest suitable (technologically and economically) facility for waste treatment/disposal. Although the New England states have the closest hazardous waste management facilities, some generators are sending wastes as far as New York, New Jersey, Ohio and Alabama. These facilities supplement Massachusetts' hazardous waste services by accepting wastes not processed in the Commonwealth or by providing extra capacity for other wastes. Some of the out-of-state facilities available to Massachusetts generators are given in Table 5.6.

III. Additional Capacity Required

The implications of capacity shortfall are expensive transportation to other states' facilities, high disposal costs due to interstate competiton for limited space in existing facilities, and the threat of illegal disposal by irresponsible generators unwilling to pay the costs of proper hazardous waste management. Strict enforcement of hazardous waste regulations, today and after the shortfall has been corrected will be necessary against the few individuals who continue to seek unsafe shortcuts to hazardous waste treatment and disposal. At present, there are adequate service companies which will accept all the waste offered (with a few exceptions for small quantities of very hazardous materials) and transport the wastes to out-of-state facilities. The existence of capacity shortfall in the state, therefore, does not at present prevent proper and legal hazardous waste management.

As a long term problem, the shortfall of disposal capacity in the Commonwealth is a serious matter. For example, until recently the bulk of hazardous waste from Massachusetts went to landfills in the Niagara region of New York. These have recently become full and are no longer available. Waste is now being shipped to Ohio and Alabama. Since we compete with a wide region of the nation at these sites, it can reasonably be expected that in a few years they will also be unavailable to Massachusetts.

By eradicating capacity shortfall and maintaining a strict regulatory program, Massachusetts will be providing improved security to its residents and its industry. Substantial benefits to health, the environment and the economy will result.

Table 5.6: SOME OUT-OF-STATE WASTE FACILITIES

Facility/Location	Wastes	Process	Capacity
Frontier Chemical Waste Process, Inc. Niagara Falls, New York	Aqueous organic chemicals Aqueous inorganic chemicals Cyanide, plating wastes	Filtration Neutralization Precipitation Oxidation Reduction Fuel additive blending Chlorinated solvent Reclamation Pretreatment for land-filling	Unknown
Liqwacon Corp. Thomaston, Connecticut	Solvents Organic Chemicals (hydrocarbon liquids)	Chlorinated solvent treatment Broker for other wastes	20,000 tons/year
Marisol Inc. Middlesex, New Jersey	All hydrocarbon liquids Aqueous organic chemicals	Reclamation Distillation	24,000 tons/year
Rollins Environmental Services, Inc. Bridgeport, New Jersey	Industrial oils Solvents, Organic chemicals, all aqueous liquids, solid chemical compounds, plating sludge, oily solids, pesticides, PCB's	High temperature incineration Chemical and biological treatment	would not disclose

Table 5.6: (Continued)

Facility/Location	Wastes	Process	Capacity
Waste Management of Alabama Emelle, Alabama	Solvents, organic chemicals, all aqueous liquids, all solids and sludges, pesticides, PCBs	Secure Landfill	
Environmental Waste Removal Inc. Waterbury, Connecticut	Oils, solvents, acid/alkali metal wastes/cyanides	Physical/chemical treatment Solvent extraction Oil separation	48,000 tons/year
Union Chemical Company, Inc. Union, Maine	All solvents, organics	Thermal distillation Incineration	4,000 tons/year
Keefe Environmental Services Epping, New Hampshire	Solvents, all aqueous waste	Physical/chemical treatment Non-chlorinated solvent physical treatment	Solvents: 8,000 tons/year Aqueous Waste: 4,000 tons/year
Resource Conservation Recovery Agency Farmington, New Hampshire	Acid/Alkali, oils, solvents	Oil/water separation Neutralization	8,800 tons/year
CECOS International Williamsburg, Ohio	All solids and sludges PCB's, pesticides	Secure chemical landfill "brand new"	3,000,000 tons

Table 5.6: (Continued)

Facility/Location	Wastes	Process	Capacity
CECOS International Niagara Falls, New York	All aqueous liquids, all solids and sludges, pesticides	Secure chemical landfill	"rapidly reaching capacity"
		Secure sludge landfill	600,000 tons, 50-55 percent full
		Wastewater treatment	640 tons/day
		Flammable solvent consolidation/brokerage	

The New England Regional Commission estimated capacity shortfall in the region in September 1979 and the following discussion is based on that study. Although the figures in Tables 5.7-5.9 have little significance relative to the needs for new facilities that will come on line in a minimum of four to five years, no better attempt at defining the longer-term hazardous waste management needs of New England has been performed.

NERCOM's study of New England capacity shortfall bears on the Massachusetts situation because of the interdependency between all New England states for present treatment/disposal facilities. Capacity shortfalls in one state are made up by the excess capacity in other states.

Tables 5.8 and 5.9 present Massachusetts' shortfall. Table 5.8 shows the distribution, across treatment and disposal options, of Massachusetts hazardous waste that must be treated off-site. Below each waste type are the possible treatment and disposal alternatives with the optimal percentage that each alternative could contribute. Estimated optimal quantities are provided in the last column. The percentages are based on NERCOM's "network analysis" for New England. Waste amounts are also based on NERCOM estimates and were initially presented in Table 5.1 of this chapter.

The volumes of wastes allocated to each treatment/disposal method in the last column of Table 5.8 are actually estimates of the capacity needs that would exist for each facility type if an optimal management program was followed. Present available capacity is not a factor. For instance, oil recovery capacity for 36,400 tons per year of waste oil would be needed under optimal conditions. Similarly, the needed capacity for a rotary kiln can be estimated by adding the amount of sludges and "chemicals and other wastes" that require such treatment (9,400-25,700 tons per year).

Table 5.9 below, provides estimates of the needed capacity for each facility type and compares this to the present capacity that exists in Massachusetts. The difference between the estimated need and the estimated capacity is the estimated shortfall, given in the last column of Table 5.9.

Because Table 5.9 represents Massachusetts only, the influence of the import and export of hazardous wastes does not appear. This accounts for the difference between the Massachusetts shortfall (Table 5.9) and the shortfall in New England (Table 5.7). Such factors are considered in the following discussion.

Table 5.7: APPROXIMATE SHORTFALL IN FACILITY CAPACITY WITHIN NEW ENGLAND IN RELATIONSHIP TO THE WASTES GENERATED
(tons/year)

Types of Facilities	Estimated Capacity Requirements Based on Wastes Generated	Current Capacity Available in New England	Estimated Capacity Shortfall
Oil Recovery	97,600	175,200	0
Solvent Recovery	82,800	21,600	61,200
Aqueous Treatment	432,000	120,800	311,200
Rotary Kiln Incineration	93,600	0	93,600
Liquid Burning Incineration			
-with scrubber	18,000	0	18,000
-with particulate control*	101,200	21,200	80,000
Secure Landfill	586,000	0	586,000

Original values converted to tons: 1 ton = 250 gallons

*The liquid hydrocarbon wastes that can be burned in an incinerator equipped only with particulate control generally have a high Btu content and are becoming increasingly valuable as fuel. In the future, companies are very likely to burn these wastes in their own boilers.

Source: New England Regional Commission, A Plan For the Development of Hazardous Waste Management Facilities In the New England Region, prepared by Arthur D. Little, Inc. September 1979.

Table 5.8: ESTIMATED OPTIMAL DISTRIBUTION OF MASSACHUSETTS HAZARDOUS WASTES ACROSS TREATMENT AND DISPOSAL OPTIONS

Waste Types and Treatment Options	Distribution Factor (%) *	Volume of Waste Allocated to Method (tons/year)
Automotive and Industrial Oils		
Oil Recovery	40%	36,400
Liquid Incineration	50%	45,500
Aqueous Treatment	10%	9,100
	100%	91,000
Solvents		
Solvent Recovery	60%	19,200
Liquid Incineration	20%	6,400
Aqueous Treatment	20%	6,400
	100%	32,000
Acids/Alkalis		
Aqueous Treatment	90%	21,600
Waste Exchange	10%	2,400
	100%	24,000
Sludges		
Rotary Kiln	10%	7,700 - 22,000
Solvent Recovery	5%	3,850 - 11,000
Aqueous Treatment	35%	26,950 - 77,000
Secure Landfill	50%	38,500 - 110,000
	100%	77,000 - 220,000

*Based on NERCOM, A Plan For the Development of Hazardous Waste Management Facilities In the New England Region, prepared by Arthur D. Little, Inc. September 1979.

Table 5.8: ESTIMATED OPTIMAL DISTRIBUTION OF MASSACHUSETTS HAZARDOUS WASTES ACROSS TREATMENT AND DISPOSAL OPTIONS (Continued)

Waste Types and Treatment Options	Distribution Factor (%)	Volume of Waste Allocated to Method (tons/year)
Chemicals and Other		
Rotary Kiln	10%	1,700 - 3,700
Aqueous Treatment	15%	2,550 - 5,550
Secure Landfill	70%	11,900 - 25,900
Waste Exchange	5%	850 - 1,850
	100%	17,000 - 37,000

Table 5.9: ESTIMATED SHORTFALL OF HAZARDOUS WASTE FACILITY CAPACITIES IN MASSACHUSETTS*
(tons/year)

Process	Estimated Need	Estimated Capacity	Approximate Shortfall
Waste Exchange	3,000 - 4,000	0	3,000 - 4,000
Oil Recovery	36,000	0	40,000
Solvent Recovery	20,000 - 30,000	8,000**	12,000 - 22,000
Aqueous Treatment	67,000 - 120,000	80,000	40,000
Liquid Incinerator	50,000	5,000	45,000
Rotary Kiln	9,000 - 26,000	75	9,000 - 26,000
Secure Landfill	50,000 - 136,000	0	50,000 - 136,000

*Massachusetts shortfall is more accurately described in a regional context. See text for discussion.

**Massachusetts has principally non-flammable solvent recovery facilities, and thus most flammable solvents must be treated out-of-state.

Waste Exchange

Although a waste exchange only accounts for 3-5% of total off-site waste, it is an economically very attractive technique. The Bureau of Solid Waste Disposal supports the concept. The New England Regional Commission has considered operating an information type waste exchange as have some other public interest groups. The Bureau will cooperate with this effort.

Oil Recovery - It appears that oil recovery facilities are in over supply in New England and thus Massachusetts needs can be met. Shipping of these valuable oils to out-of-state recovery facilities is economically feasible. The supply of waste oil will probably decrease as oil prices increase, but capacity in all disposal areas must be monitored. This is one purpose of this annual statewide environmental impact report.

Solvent Recovery - New England has too little capacity for solvent recovery. At present an additional unit in Massachusetts or an expansion of an existing plant is required.

Over the longer term the amount of solvents to be disposed of off-site of the generator's plant will undoubtedly decrease. The reason for this is that the increasing costs of petroleum make solvents increasingly valuable to recycle or to burn as fuel. Most larger generators are expected to move in this direction. An exception is the dry cleaning industry and small shops which use small quantities of solvent. They are unlikely to install the capital equipment for recycling and will depend upon an outside solvent recovery facility.

The data are simply not available now to make a prediction of the need for solvent recovery facilities in five years. Fortunately, they are low in capital costs, profitable and have little environmental impact. Given a reasonable public acceptance of siting, the disposal industry will, with a high probability, be willing to meet the demand for disposal on a speculative basis. They will be willing to operate the facilities below capacity in the future if demand falls, expecting to obtain a return on the investment even in such an unfavorable business situation.

Aqueous Treatment - It appears that additional capacity will be needed in Massachusetts, but the range of data is large. This is due to the many decisions which must still be made that affect the production of aqueous liquid wastes.

Aqueous liquid wastes that are treated off-site are mostly inorganic

and come chiefly from the plating or photographic industries or from the metal working industries. They contain cyanides or heavy metals and can be precipitated or detoxified on site. The results of this treatment can range from clean water to heavy metal sludges. It depends upon the process chosen, which depends upon economics and is greatly influenced by the cost of disposal of the sludge and the value of the metals recycled. With disposal costs and metal prices rising, it can be assumed that disposal on-site using low sludge producing processes will be increasingly used.

Ferrous metal industries, like foundries, produce liquid acid waste from metal cleaning with very little metal value. Much of this has been handled in the past by deep well disposal or ocean dumping. These options are closing. On-site treatment with production of ferrous sludges for landfill disposal is likely to increase.

Thus, again the picture is mixed. Fortunately, aqueous treatment facilities are the most innocuous of any of the hazardous waste treatment processes and an additional unit in Massachusetts should present small financing or siting problems.

Liquid Incineration - Liquid incineration typically handles organic wastes that cannot easily be burned as fuel, either because of their chemical content, e.g. chlorine compounds, or their consistency, e.g. heavy and sticky. One way to utilize those wastes as fuel is to burn them in industrial equipment which can tolerate their characteristics. Thus, chlorinated organics can be burned in cement kilns, as discussed in Chapter 2.

With increasing petroleum prices and higher costs for proper disposal, there will be increased economic incentive to use these organics as fuel. Thus, the 45,000 ton/year short fall in liquid incinerator capacity may decrease.

It does appear likely, however, that one or two facilities may be required. These can probably best be sited as part of an oil/solvent recycling plant. Another option for liquid incineration is in a rotary kiln incinerator. Use of part of the rotary kiln capacity for liquids is justifiable as a small fraction of the total heat load and to support the combustion of difficult to burn materials.

Rotary Kiln Incineration - The burning of organic solids, oil-soaked earth (as from a spill clean-up), or organic sludges requires a rotary kiln. No such facility exists in New England, and there are few modern facilities of this type in the United States despite the fact that they have been used for a decade in Europe.

The estimated waste in Table 5.9 that requires rotary kiln incineration is sufficient only to support about half the capacity of a modern facility of the size common in Europe. However, the Commonwealth often needs such a facility desparately, when there is a spill or a clean-up of an illegal site. On the average a major oil spill occurs once a year in Massachusetts and there is a minor spill on the average of once per day. It is inordinately expensive to haul the large quantities of contaminated earth out of state to a secure landfill.

We also anticipate that the pre-treatment requirements of the MDC and other sewage districts will produce much increased quantities of organic sludges. These also should be rotary kiln incinerated.

The addition of the variable and relatively unmeasured spill and clean-up residue plus the additional pre-treatment sludge will probably produce sufficient total to support a 25-50,000 ton/year rotary kiln incinerator in the Commonwealth. An additional source of waste for combustion could be some of the liquid waste, as discussed above.

In summary, the Commonwealth appears to need a rotary kiln incinerator of 25-50,000 tons/year capacity. Much more study of the demand is required before this can be stated with assurance.

Secure Landfill. - The amount of waste in Massachusetts estimated to required landfill disposal is 50-136,000 tons/year. This number is extremely uncertain. The volume of certain aqueous sludges can be reduced by advanced de-watering techniques or their volume can be decreased by more sophisticated tech-nology, say, for plating waste treat-ment on-site. On the other hand, the enforcement of pretreatment regulations before aqueous discharge to sewers could increase the amount of inorganic sludges that must be landfilled. Similarly, it is uncertain whether the estimates for landfill demand include some combus-tible wastes which are permitted to be landfilled by U.S. EPA regulations but not under the new Massachusetts law. Removal of these materials would decrease landfill demand.

Despite this uncertainty it is clear there will be non-combustible wastes and irreducible residues from treatment processes to be landfilled. Since there is no hazardous waste landfill in Massa-chusetts, we are certainly going to need one.

Appendix A: Types of Wastes

Thousands of different compounds are classed as hazardous under federal and state regulations. For ease of consideration these can be combined into a relatively small number of waste types that share at least some general properties. The options for treatment and/or disposal may vary greatly within one category.

For the purposes of this appendix we include the following waste types:

1. Chlorinated solvents
2. Non-chlorinated solvents
3. Waste oil
4. Acids/Bases
5. Developers, Fixers, Ink
6. Polychlorinated Biphenyls (PCB's)
7. Paint wastes
8. Heavy-metal sludges
9. Still bottoms
10. Resins
11. Asbestos
12. Sand-blast grit
13. Leather scrap

Each type of waste is described in more detail below.

Typical Waste Types

1. Solvents (Chlorinated)

Characteristics:	Chlorinated solvents are generally aromatic, colorless liquids. These solvents have low boiling points and are generally non-flammable.
Examples:	Methylene chloride, trichloroethane, trichloroethylene, tetrachloroethylene.
Sources:	These wastes may be generated with paints, degreasing operations, dry cleaning, and plastics processing.
Hazards:	Prolonged inhalation of these compounds may cause headaches, drowsiness; many are irritating to eyes, nose and throat. Trichloroethylene and trichlorethane may cause liver and kidney damage.

2. Solvents (Non-chlorinated)

Characteristics:	Non-chlorinated solvents are generally aromatic, colorless liquids. Most of these solvents have low flash points and boiling points. Most are heavier than air, and the vapor may travel a considerable distance to a source of ignition and flashback.
Examples:	Benzene, acetone, toluene, methyl ethyl ketone
Sources:	Non-chlorinated solvent wastes are found mixed with unused paint mixtures; oil mixtures from degreasing operations; rubber mixtures; adhesives and cements; and cleaning fluid residues.
Hazards:	Many of these chemicals can form explosive mixtures with air. Most vapors are toxic by inhalation and some are toxic (xylene and toluene) by skin absorption.

3. Waste Oils

Characteristics: These are petroleum distillates which are dark brown or black in color. Generally, the flash point is above 200°F. Automotive waste oils are generally manufactured for special lubricating conditions and many are polymers of olefinic hydrocarbons.

Examples: Hydraulic oils, turbine oils, cutting oils, fuels

Sources: Automatic maintenance, machine lubrication (often combined with solvents and other toxic compounds).

Hazards: Lubricant additive may contain toxic and/or carcinogenic compounds such as phenols or formaldehyde. Some mixtures may be ignitable.

4. Acids-Alkalis

Characteristics: These are liquid compounds with a pH less than or equal to 2 (acid) or a pH greater than or equal to 12.5 (alkali); these chemicals are corrosive.

Examples: Sulfuric acid, hydrochloric acid, oxalic acid, caustic soda, lime.

Sources: Metal finishing, electroplating, electrical circuit manufacture, foundry, photo processing, laboratories, chemical industry, leather tanning.

Hazards: Concentrated acids react violently with concentrated alkalis. Most of these chemicals are highly toxic by ingestion, corrosive to body tissue, and inhalation may cause damage to lungs.

5. Developers-Fixers-Inks

Characteristics:	Fixer/bleaches contain reclaimable quantities of silver. Other photo processing compounds contain cyanides, formaldehyde, hydrazine, acetic acid, sodium hydroxide, benzol alcohol, ethyl diamine, hydroquions and bleach. Inks contain organic compounds.
Examples:	Developers, stabilizers, stop baths, bleach, fixers, mordant dyes.
Sources:	Textile manufacture, publishing, printing, photo and X-ray processing.
Hazards:	Hazards from this class of wastes include toxicity, corrosivity, and carcinogenicity.

6. PCB (Polychlorinated Biphenyl)

Characteristics:	These are colorless liquids with boiling points in the range of 644°F to 707°F. They have flash points of 383°F. PCB's are generally non-corrosive to metals and non-oxidizing. They are extremely stable compounds and do not degrade easily.
Sources:	PCB are bound in electrical transformers and capacitors. These wastes are generated in transformer repair facilities and power stations.
Hazards:	Material is highly toxic by ingestion, inhalation and skin absorption. PCB are suspected carcinogens and are virtually indestructable in a natural environment. This material also accumulates in fatty tissues in humans.

7. Paints Waste

Characteristics: Paints are liquids with a variety of colors. These materials may be waterbased, oil or resin-based (latex). This material may contain solvents, organic-tin compounds, lead, copper, chromium and other toxic compounds.

Examples: Anti-fouling paints, lacquers.

Sources: Metal maintenance areas, manufacturing processes.

Hazards: Organic-tin paints are highly toxic to skin, eyes, and respiratory tract. Dust particles from removal may be irritating to the respiratory tract. Heavy metals will accumulate in body tissue.

8. Heavy Metal Wastes

Characteristics: These are generally compounds dissolved in water or mixed with sludges. Heavy metals include - barium, cadmium, chromium, lead, mercury, selenium and silver and select compounds of other metals listed in 40CFR 261.

Examples: Zinc phosphide, chromic acid, gold cyanide, cadmium sulfate.

Sources: Metal finishing industry, electroplating, fluorescent lamps, pharmaceuticals, paints, photo processing.

Hazards: Generally heavy metals accumulate in body tissues and have toxic effects ranging from liver and kidney damage to central nervous system disorders.

9. Still Bottoms

Characteristics:	Tar or sludge material; product of solvent or oil distillation.
Examples:	Trichloroethane distillation sludge.
Sources:	Recycle/reclamation operations, electroplating, metal finishing.
Hazards:	Waste contains toxic material dissolved in solvents and health hazards are similar to those described for solvent wastes.

10. Resins

Characteristics:	Resins are organic compounds known as polymers, which, when heated, set to form a tough, durable material. Some resins can be melted and reformed while others once set cannot be remelted. Waste resins can be a mixture of the two types but would more likely be the hard, non-melting type.
Examples:	Phenol formaldehyde, urea formaldehyde, epoxy resins.
Sources:	Chemical manufacturing, rubber and plastics industry, resin-based paints, electrical and electrical appliance manufacturing.
Hazards:	Most thermosetting resins contain formaldehyde and/or phenols which are toxic materials.

11. Asbestos

Characteristics: White/gray clothlike material; extremely fire resistant.

Sources: Asbestos pipe or boiler insulation, brake relining operations, fire retardent building material.

Hazards: Asbestos may cause impaired breathing in exposed workers and may lead to disabling fibrosis or scarring of the lungs known as asbestosis. It may also cause rare cancer which attacks lungs and abdomen (mesothelioma).

12. Sandblast Abrasives

Characteristics: This material generally consists of a hard, crystalline material. Each particle has a large number of sharp edges which is the desired property for a blasting abrasive. The spent abrasive is mixed with chips of paint which contain heavy metals.

Sources: Sandblast paint removal operation.

Hazards: The paint chips mixed with the spent abrasives contain heavy metals, chiefly chromium, lead, and zinc. Health hazards associated with these heavy metals have been outlined earlier.

13. Leather Wastes

Characteristics: This material consists of blue hides and leather scraps. Leather scraps are the remains of a hide after the desired product shape has been cut out. Blue hides are leather scraps that are heavily contaminated with chromium used in the dehairing step of leather tanning. The chromium is responsible for the light blue color of the hides.

Sources: Leather tanneries, shoe making industry.

Hazards: Chromium is the major hazard associated with these wastes. This metal can accumulate in body tissue and create long-term toxic effects.

Appendix B
Sample Pages from the Midwest Industrial Waste Exchange, Clearinghouse and News

The following pages are excerpts from the Clearinghouse and News of the Midwest Industrial Waste Exchange (MIWE).

The MIWE was organized in 1975 and began publishing the catalog of wastes in 1976 from St. Louis, Missouri. The St. Louis Regional Commerce and Growth Association and the Chamber of Commerce of Greater Kansas City co-sponsor the catalog.

The Clearinghouse Catalog is published quarterly and lists two types of items: available and wanted. A $10 per item listing fee covers publication in three consecutive issues. Letters of inquiry are sent to the MIWE in response to a listing. The Exchange then either forwards the letter to the listing firm (if the listing firm requests confidentiality) or notifies each part of the other's identity. The Exchange does not participate in any negotiations between the parties.

ITEMS WANTED

Code Identification: W8-1

Item: Metal Sludges or residues & grindings with up to 75% water or oil or in mixture. Metal content interested in is Co, Mo, Ni or W.
Quantity Desired: 500 lbs minimum
Location: Midwest

Code Identification: W8-2

Item: Cinders (clinker type)
Quantity Desired: 100-800 tons/month
Location: Midwest

Code Identification: W8-3

Item: Fly Ash (Class F preferred)
Quantity Desired: 100-300 tons/month
Location: Midwest

Code Identification: W8-4

Item: Metal waste and residues containing economic quantities of Co, Cd, Ni, Mo, Cu, W, Se, Te, Bi, Sn.
Quantity Desired: any economic quantity
Location: Midwest

Code Identification: W8-5

Item: Combustable Solvents
Quantity Desired: 5,000-30,000 gal/month
Location: Midwest

Code Identification: W8-6

Item: Zinc Oxide (Baghouse dust - preferred dry) Zinc Oxide from cletroplating operations or other intermediate processes.
Quantity Desired: any large amount on a continous year round basis
Location: Midwest

Items Available

Code Identification: A9-1

Item: Coarse Sawdust mixed with Wood Chips. Species:
1. Canadian Spruce - Pine and Fir
2. Douglas Fir
3. Hemlock
4. Mixed White Woods

Availability: 18 tons per week. Bulk.
Location: Missouri

Code Identification: A9-2

Item: Spent Nitric Acid with approx. 1 lb/gal Nickel and 1/2 lb/gal Copper.
Availability: Approx. 560 gals/6 months (drums).
Location: Wisconsin

Code Identification: A9-3

Item: Spent Aqueous Muriatic (Hydrochloric) Acid, HC1., 15% HC1, 0.5% NH_4C1, approx. 84-85% H_2O (Water).
Availability: 15,000 gal/day. Bulk.
Location: Tennessee

Code Identification: A9-4

Item: Waterbase Paint Sludge:
Acrylic & Vinyl Resins 53-57%
Water (H_2O) 30-32%
Solvents 9-11%
Alcohols 3-4%

Availability: 2,000 gals/month in 55 gal. drums.
Location: Missouri

Code Identification: A9-5

Item: Used Solvents - Xylene, Ketones, Aromatic Hydrocarbons, Glycol Ethers with 5-20% Inorganic Pigment Contamination.
Availability: 10,000 gals/month in 55 gal. drums.
Location: Missouri

Appendix C
United Nations Economic Commission for Europe.
Report on the Program on Low- and Non-Waste Technology

The following pages are excerpts from a United Nations report on low- and non-waste technologies. The report, still unpublished, will be a compilation of process designs that can be substituted in some industrial practices to reduce or eliminate the generation of hazardous waste. More information may be obtained from the Economic Commission for Europe, Palais de Nations, 1211 Geneva 10, Switzerland, or by calling the ECE office of the United Nations (212) 754-5755.

United Nations
Economic Commission for Europe
Program on
Low-and Non-Waste Technology

Introduction

The purpose of this program description is to familiarize interested parties with the objectives and requirements of the United Nations Economic Commission for Europe (ECE) program on low-and non-waste technology.

The low-and non-waste technology program consists of two projects:

1. Sub-project A is concerned with the compilation and dissemination of a compendium of available up-to-date knowledge regarding industrial low-and non-waste technology; and

2. Sub-project B deals with the development of methods and criteria for assessment and comparative analysis of industrial technologies, and the testing of these methodologies on specific technologies identified in sub-project A.

The program description contained within this document is concerned with the sub-project A, compilation and dissemination of a compendium on low-and non-waste technology.

Description of Low-and Non-Waste Technology

Low-and non-waste technology has been defined by the Senior Advisers to ECE Governments on Environmental Problems as:

> "the practical application of knowledge, methods and means so as to provide, within the needs of man, the most rational use of natural resources and energy and to protect the environment."

The project places emphasis both on technological modifications that lead to the creation of less waste, through greater physical efficiency of energy and materials use, and on those processes that convert waste products from conventional processes into new secondary products (by-products) that can be used by other industries. Examples of activities in this field which would qualify are as follows:

1. The design of products in order to minimize the use of energy and/or raw materials, either during manufacture, use, or disposal/recovery;

2. The design and operation of production processes in order to minimize energy and raw materials usage;

3. The design and location of manufacturing plants in order to facilitate the use of waste materials and energy from one plant to another;

4. The design and operation of waste handling processes in order to recover "residuals;" and

5. The design and operation of central "waste exchanges" in order to permit the residuals from one industry to be converted into raw materials for another or the same industry.

An up-to-date knowledge of these types of activities will be summarized in a compendium which will receive world-wide distribution.

Requirements for the Compendium of Low-and Non-Waste Technology

The compendium shall consist of a monograph and a summary of the technology description. The monograph shall contain a detailed description of the low-and non-waste technology as well as the conventional technology. The materials and energy requirements, the form and amounts of waste generated, investment requirements and unit production costs should also be compared.

Areas of the descriptions and comparisons which would require data of a proprietary or restricted nature should be identified. It is expected that the monograph will contain sufficient information to determine the applicability of the low-or non-waste technology, and potential users would contact directly the company holding the proprietary information. The monograph should not exceed twenty pages. A description of its format is contained in Attachment A. In addition, a one page summary should be prepared. An example of a typical monograph and summary is shown as Attachment B.

Compendium Collection and Dissemination

Monographs and summaries, prepared by the interested participants, should be forwarded to the following:

Marvin B. Rubin
National Focal Point for ECE's
Low-and Non-Waste Technology Program
Department of Commerce, Room 3425
Washington, D. C. 20230

The national focal point is responsible for reviewing the submitted material for ensuring its suitability and completeness, and for forwarding copies to the ECE.

Once the monographs have been received by the ECE, they will be assessed with the help of consultants; circulated to all of the national focal points for review; and approved by the focal points for inclusion in the compendium.

The compendium will be distributed by the ECE Environment and Human Settlements Division to each of the national focal points for subsequent dessemination within their respective (ECE member) countries. The United Nations Environment Program (UNEP) Office will be responsible for preparing additional copies of the compendium for its own needs and for distribution to non-ECE countries.

Following distribution of the compendium, governments and industries wishing further information regarding a given technology, or desirous of utilizing the technology, may contact the company that developed the technology.

Example of Typical
Low-and Non-Waste Technology
Monograph and Summary

Subject:

The Elkem Closed Ferrosilicon Furnace
With Split Furnace Body

Prepared by:

Elkem - Spigerverket a/s, Oslo, Norway

SUMMARY OF LOW- AND NON-WASTE TECHNOLOGY (L/NWT)

1.	INDUSTRY	Silicon/Ferrosilicon
2.	CONVENTIONAL TECHNOLOGY	Open top furnace without or with bag house filter.
3.	LOW- AND NON-WASTE TECHNOLOGY	A. Semi-closed furnace w/waste heat boiler and filter. B. Closed furnace w/filter and gas fired boiler.
4.	STAGE OF DEVELOPMENT OF L/NWT	A. All steps developed in industrial scale. B. Small industrial furnace developed. Filter to be installed in 1979.
5.	REPORTING ORGANIZATION	Elkem-Spigerverket a/s, Oslo, Norway
6.	DATE OR REPORT	1st September 1979.

7. PROCESS DESCRIPTION OF L/NWT AND IDENTIFICATION OF DIFFERENCES COMPARED TO CONVENTIONAL TECHNOLOGY

<u>Conventional Technology</u>

Typical for the conventional technology, the open furnace, is that the reaction gases burn on top of the burden with a large amount of excess air. The purpose of the excess air is to cool the burning gases to reduce strain on furnace equipment. A bag house filter can be used for cleaning. The gas/air mixture amounts to approx. 15 Nm^3 per kWh of electrical input to furnace.

<u>Low- and non-waste technology</u>

A. Semi-closed furnace.
The main idea with the semi-closed furnace is to restrict the amount of excess air to elevate the temperature of the off-gases making energy recovery feasible. The off-gas amount is restricted to 2-5 Nm^3 per kWh of electrical input to furnace. The energy is recovered in a special waste heat boiler, and the cooled off-gas is cleaned in a bag house filter. The size of the bag house filter is proportional to the amount of off-gas drawn off the furnace.

B. Closed furnace.
The closed furnace has a gas-tight cover, and the gas, as rich CO-gas, is collected without being burned above the charge surface. The gas volume to be cleaned is small compared with the volumes from the open and semi-closed furnaces, theoretically only 2 per cent of the volume from an open furnace.
Cleaning in wet venturi scrubbers is an established technology, but the method is not encouraging due to the sophisticated sludge treatment plant required to comply with pollution standards.
Development work is therefore concentrated on dry filtering of CO-rich gas from ferrosilicon furnaces. An industrial scale filter will be started up primo 1980. The cleaned CO-rich gas can either be used as process gas, or burned in a conventional steam boiler.

8. OTHER SIGNIFICANT ASPECTS OF L/NWT

Recovered energy in per cent of electrical input to furnace will be in the range of :
1. 65-75 per cent with steam as end product.

GENERAL CHARACTERISTICS OF SILICON/FERROSILICON FURNACES

The general design of reduction furnaces employed in the smelting of the bulk types of ferroalloys is basicly the same.

The essential job assigned to the reduction furnace is to supply the high temperature and energy the chemical reactions require. Reaction products are to be smelted and superheated so that they can be readily drained through the furnace tap-hole and poured for casting. Raw materials are fed on to the top of the furnace. Power is applied to the electrodes which stay buried in the charge, and heat is dissipated in the reaction system through resistance, and arcing from the tip of the electrodes.

Gases and vapours generated in the reaction zones surrounding the electrodes escape through the furnace charge. A certain amount of heat is exchanged between hot gases and decending solids. The gas eventually rising out of the top is rich in carbon-monoxide and carries fumes from the high temperature regions of the furnace. It also entrains finer sized constituents of the charge.

CONVENTIONAL TECHNOLOGY

Until recently the reduction furnaces for silicon/ferrosilicon were built with open tops only and with an entirely uncontrolled waste gas system.

In this design the combusted gases are collected by a furnace hood and vented through stacks to the atmosphere. Through natural draft the burned reaction gas is diluted and cooled with large quantities of air leading to large stack gas volumes of moderate temperature. Conventional furnace hood design will admit stack gas volumes in the range of 15-20 Nm^3/kWh. Consequently, a medium size, 20 MW ferrosilicon furnace will emit waste gas at a rate of 300-400.000 Nm^3/h. Of this volume the actual reaction gas account for only about 2 percent. Emission from such an open top furnace is for all practical purposes just hot air, except that it entrains particulate matter in the low concentration range of 1-4 g/Nm^3.

The solids, being mostly fumes in sub-micron sizes, cause a highly visible emission. An open top furnace is easily recognized as a heavy polluter, and efficient gas cleaning is difficult and expensive. Faced with the problem of cleaning the extremely large volumes of gas emitted from open top furnaces, ideas on ways and means for limiting the quantity of air immediately spring to mind. For various reasons dry filtering in bag house type of equipment is so far considered to offer the mose appropriate solution on the cleaning side. Since filter investment and operating costs, as well as filter power consumption, are approximately proportional to volumetric gas flow, measures for reducing volumes are particularly rewarding.

In existing conventional furnace design there are usually limited possibilities for a closer hooding due to the fact that a reduction of the dilution air volume will cause a temperature rise which is dedritmental to the equipment.

LOW-WASTE TECHNOLOGY

A. Semi-Closed Silicon/Ferrosilicon Furnace

The first step towards the semi-closed furnace was the design of the low hood type. On this furnace type there is a concentration of equipment above the hood roof, away from the heat. Simplicity and sturdiness characterize the arrangement underneath the hood. This is illustrated in Fig. 1. The semi-closed furnace can be described as a low-hood furnace equipped with hood side-walls extending to the top of the furnace body, and movable doors to allow access for stoking, etc. This furnace type is designed for high temperatures, and hence for reduction of the dilution air volume, and offers at the same time improved working conditions due to closer hooding.

Reduction of the smoke volume to be cleaned made possible by the semi-closed furnace, reduces the cost of cleaning. However, to bring the smoke temperature below the limits set by the filter

bag material, cooling becomes necessary.
A gas to air heat exchange arrangement has been frequently used in the past. Today the trend is to raise the temperature of the gas to 800-1200°C and to use a waste heat boiler to handle the dual task of recovering the energy and cooling to a temperature acceptable to the bags.

B Closed Silicon/Ferrosilicon Furnace

By definition the closed furnace has a gastight cover so that the reaction gases are drawn off unburned. The gas volumes will thus be small, down to 2 percent of the volume from open top furnaces.

The small gas volume to be cleaned is one attractive aspect of the closed furnace. Another is that the unburned gas represents a more valuable resource than the burned gas, and offers more flexibility in usage :

- heating purposes,
- production of steam for heating purposes or for production of electrical power via steam-turbine,
- process gas for chemical processing.

Due to these advantages the closing of a ferrosilicon furnace has attracted attention over the last decades.

What then are the reasons for the slow progress in closing the high-grade ferrosilicon furnace bearing in mind that the closed furnace is the normal choice for practically all other electro-metallurgical products ?

The main hold back is to be found in the characteristics of the silica-carbon reaction system in which condensing and escaping of silicon-monoxide easily leads to gas blows, crust formations, high losses and temperatures. Free access to the furnace top

for stoking has therefore always been a must in order to maintain a good operation on high-grade ferrosilicon.

When Elkem-Spigerverket a/s decided to start the closed ferrosilicon furnace project in 1974, new means for stoking the charge mix in the furnace had to be developed.
Conventional stoking through gastight seals in the cover was subject to a thorough study. Parallel with this evaluation, work was started on a completely new concept without stokers, but where the furnace body was given a special design.

From fig. 2 can be seen that the furnace body has been devided in two parts, one lower and one upper, the interior cross-section of the upper part being given the shape of a regular polygon, typically with nine sides.

The bottom part, which is the main furnace body, and the upper part, which is referred to as the ring, may be rotated independently of each other. In principle, any combination of rotation or oscillation of the two bodies may be applied.

The effect of the split furnace operation is a bulk effect in the charge, transplanted radially inwards from the circumference, and downwards from the top surface. An indication of these effects can be seen when observing the furnace top. Visual observation can, however, only give a vague indication of the total effect on the charge. Due to different velocities of the upper and lower parts of the split furnace body, the charge around the dividing plane between the parts will be exposed to a shearing/kneading effect which results in a non-sticking, porous charge.

An open furnace of 8.5 MW capacity at Bremanger Smelteverk was chosen for conversion to a completely closed furnace for operation on 75 per cent ferrosilicon.

Figure 3 gives an overall view of the equipment at the operating platform. A typical feature is the high position of the furnace cover. Through the open side wall of the cover the regular polygon of the ring can be clearly seen.

Test operation on this furnace was started in 1977. After the first half year of adjustment of equipment and refining of the process, the furnace has been operated without major problems. In fact the furnace for some time now has been looked upon as a regular production unit.

The furnace has so far been operated without gas cleaning. Typical gas analyses are : CO 65-80 %, CH_4 0-4 %, H_2 12-25 %, N_2 1-3 %. The dust particles are larger than the particles from an open furnace, and they have a tendency to form agregates which makes the dust from a closed furnace more easy to precipitate f. inst. in a wet scrubber. Cleaning in wet venturi scrubbers has been tried, and is an established technology, but the method is not encouraging due to the sophisticated sludge and water treatment required to comply with pollution standards.

In our strategy for the closed ferrosilicon furnace, we have decided to verify two alternative methods of handling the gases :

1. Dry filtering of the CO-rich gas.

   - Promising tests in a small test unit are accomplished.
   - A full scale filtering unit is under erection, and will be started up primo 1980.

   The cleaned gas can be used as :

   - process gas for chemical processing.
   - fuel for steam boiler for production of steam for heating purposes or for production of electrical power via a steam turbine.

2. Burning the uncleaned, CO-rich gas in a special developed steam boiler.

- Promising tests in a small test unit are accomplished.

  The steam produced can be used for heating purposes or for production of electrical power via a steam turbine. The burnt and cooled gas leaving the steam boiler can be cleaned in a bag house filter.

ENERGY RECOVERED WITH LOW-WASTE TECHNOLOGY

The most efficient use of the recovered energy would be to utilize the steam for heating purposes, or for the closed furnace alternative to utilize the CO-rich gas as fuel for chemical processing. Such solutions are known, but the condition is a favourable plant location where the neighbouring industries are big consumers of either steam, hot water or process gas. Due to secluded locations, however, there is most often no other option than to convert the gas to electric power. By doing so roughly two-thirds of the energy in the steam is lost in condensation of the exhaust steam from the turbine, in line with what is normal for steam power plants.

The energy recovered in per cent of electrical input to the furnace will be in the range of :

- 65-70 per cent with steam as end product.
- 20-25 per cent with electrical power as end product.

Type of reductants and mode of operation will influence on these figures.

So far we have no practical experience in producing steam or electricity with gas from a closed furnace. Theoretical evalutions indicate that energy recovery based on CO-rich gas from the closed furnace will be more efficient than recovery from a semi-closed furnace.

EVALUATION OF PRODUCT COST

The major stages in the development of the ferrosilicon furnace - leading up to the closed type - is illustrated in a simple way below.

I OPEN FURNACE

II OPEN FURNACE WITH BAG HOUSE FILTER

III SEMI-CLOSED FURNACE WITH BAG HOUSE FILTER

IV SEMI-CLOSED FURNACE WITH ENERGY RECOVERY SYSTEM AND BAG HOUSE FILTER

V CLOSED FURNACE WITH GAS CLEANING AND ENERGY RECOVERY SYSTEM

A natural question to ask at this point is "What main factors have caused this development to happen?"

One of the most important factors behind the chain of development has probably been the various countries' introduction of strict regulations on air- and water pollution control, forcing the metallurgical industry to change the regular concept of a standard metallurgical plant lay-out.

Furthermore, the recent invention of the split furnace body has put the last stage - the closing of a commercial high grade ferrosilicon furnace - within reach. This has been a challenge to the industry for more than 25 years after the first tests to collect unburned gas from a 75 % ferrosilicon furnace were carried out in Norway back in 1950.

As one can see, the introduction of stringent air pollution control triggered off a chain of events which commencement beyond the first were obviously aided by the industry's natural wish to reduce cost in a world where energy, manpower and equipment costs have a tendency to go in one direction only,

namely upwards. Strict regulations also on water pollution, the next step will be the development of a low cost, dry system for cleaning of gas from closed ferrosilicon and silicon metal furnaces, and a considerable amount of effort is being directed by Elkem-Spigerverket a/s towards this goal today.

To produce efficiently at low cost is a key to any industry's success and possibility for growth. In the production of 75 % ferrosilicon, the major cost items are

Raw Materials
Electrical Energy
Labour

and they account for more than 80 % of the total cost. Consequently, alterations in the design itself can only to a small degree contribute to a saving in the production costs. The relative importance of the three items will obviously vary with the unit cost of each one. Labour and electrical energy are probably the two items which show most variation from one country to another. In Norway, the cost of total manpower and cost of electrical energy will be roughly the same at a unit price of approx. 5.5 mills per kWh based on the production of 75 % ferrosilicon.

With increasing power costs, it follows then by logic that energy recovery systems represent obvious cost saving factors to consider for the electro-metallurgical industry to be able to meet todays keen competition.

When considering the five furnace types and combinations referred to earlier, how does the cost vary in the production of one ton of 75 % ferrosilicon ? Based on a 20 and a 40 MW furnace and a unit price of 10 and 30 US mills per kWh respectively, the picture will be as shown in fig. 4, using the closed furnace with energy recovery system, as a reference of 100 in each case.

From this figure one can draw the following conclusions

The higher the power cost

- the more savings through energy recovery

The closed furnace with energy recovery

- most economical solution

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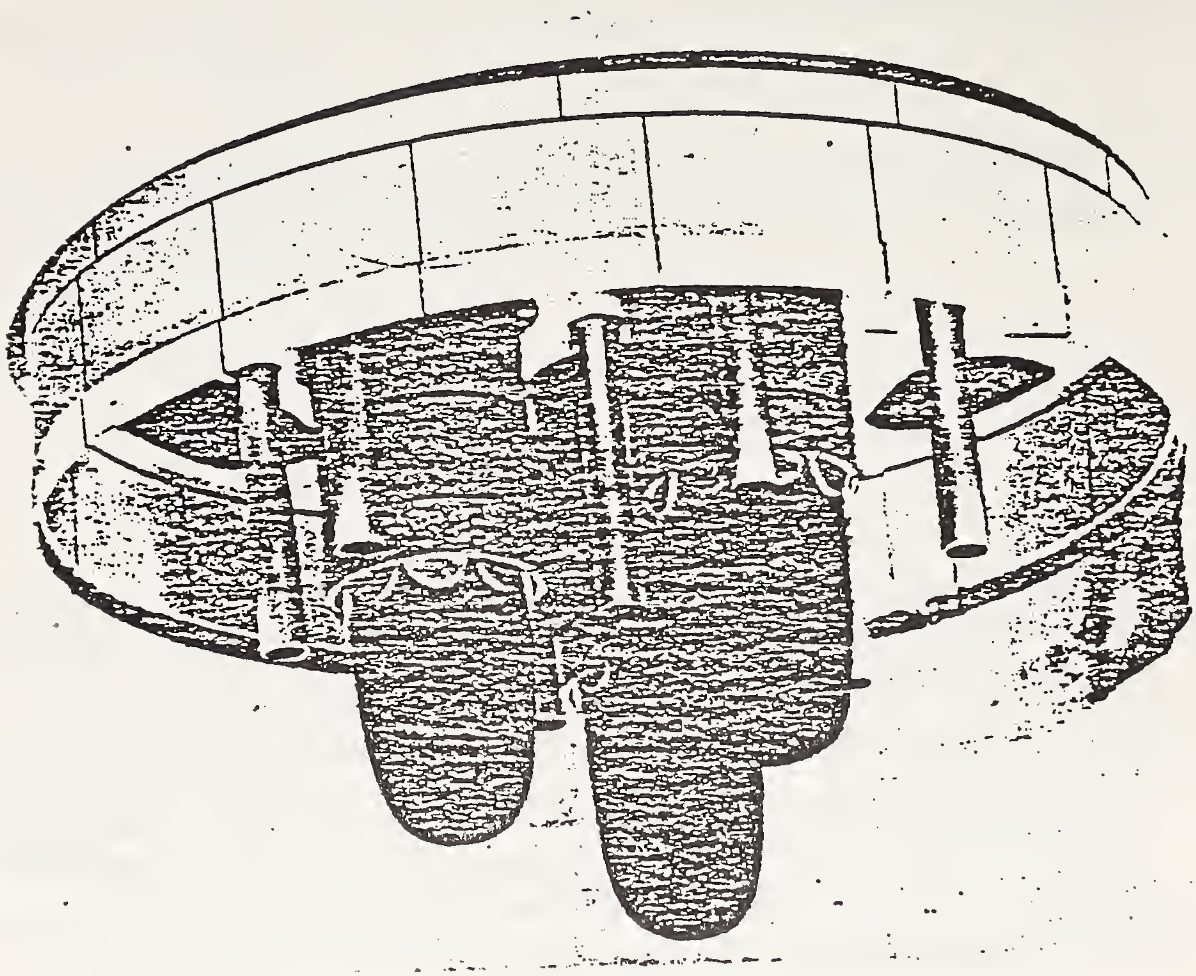


Figure 1 Model of low hood furnace indicating the simplicity and sturdiness of the equipment underneath the hood.

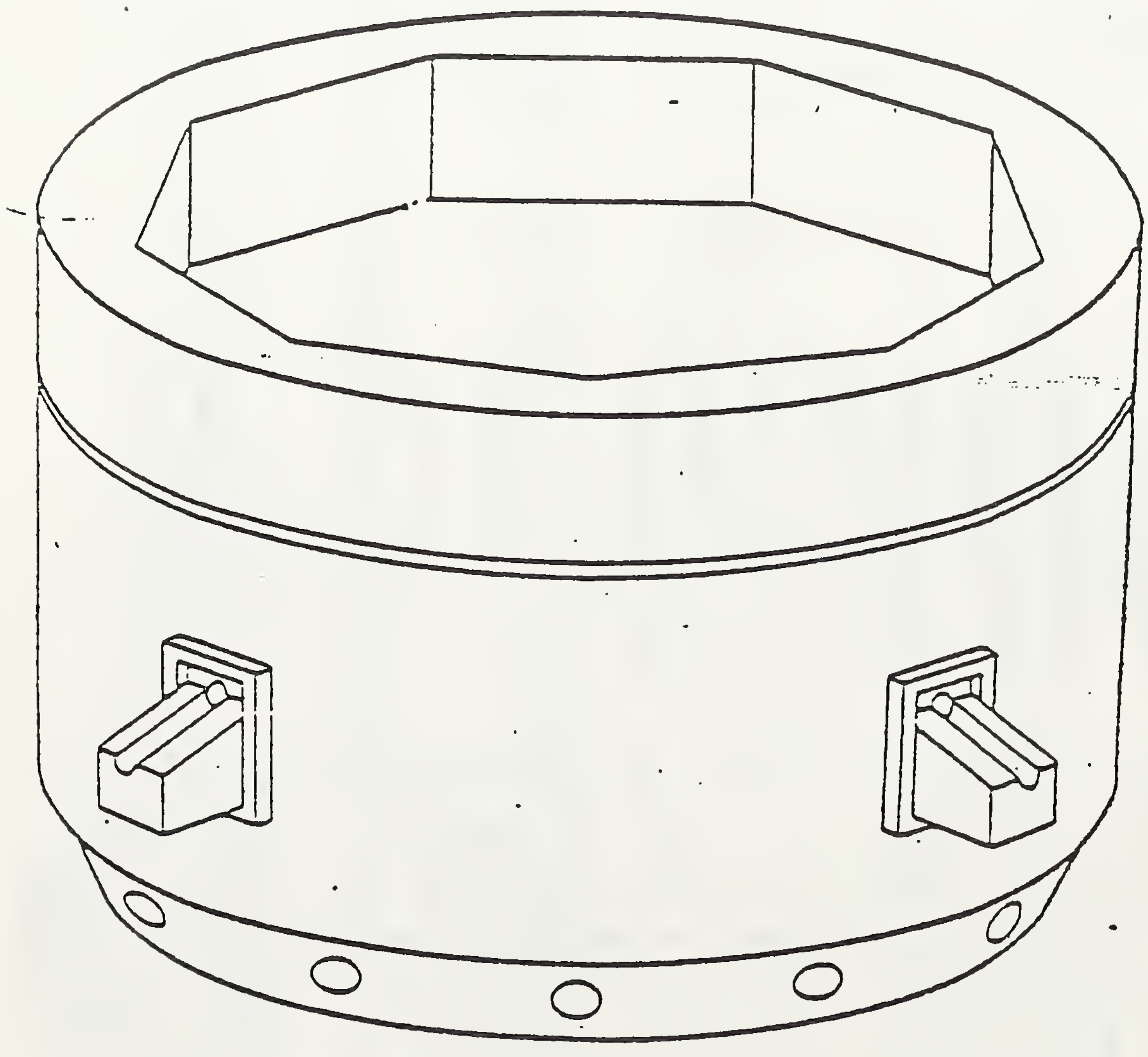
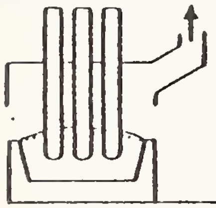
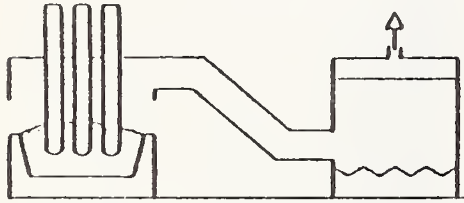
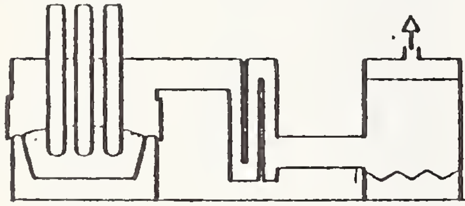
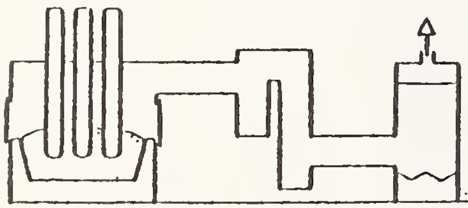
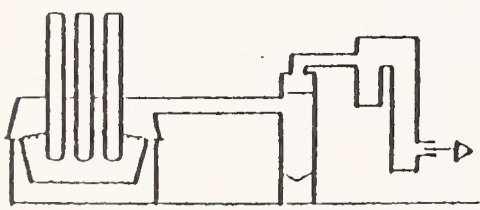


Figure 2 Model of The ELKEM Split Furnace Body. Any combination of rotation or oscillation of the upper and lower bodies may be applied.

FIG. 4 RELATIVE COST FIGURES FOR PRODUCTION OF 75 PER CENT FERROSILICON

		20 MW F'CE		40 MW F'CE	
		US mills per KWh		US mills per KWh	
		10	30	10	30
	OPEN FURNACE	100	109	102,5	112
	OPEN FURNACE BAG FILTER	106	114	108	117
	SEMICLOSED F'CE COOLER BAG FILTER	105	113	107	116
	SEMICLOSED F'CE ENERGY RECOVERY BAG FILTER	103	104	103	104
	CLOSED FURNACE GAS CLEANING ENERGY RECOVERY	100	100	100	100
CONVERSION FACTOR GIVING THE RELATIVE COST OF THE FOUR ALTERNATIVES		1,20	1,54	1,00	1,34

Appendix D: Siting Criteria

The Massachusetts Hazardous Waste Siting Act specifies the procedures that must be followed before any hazardous waste management facility can be developed in the Commonwealth. The Department of Environmental Management is preparing a Hazardous Waste Facility Siting Manual as a guide to the siting process. The Manual is expected to be available to the public in March, 1981.

Criteria which will be used to evaluate proposed facility locations will be set out in the Siting Manual. Some criteria being considered are presented below:

A. Unacceptable Conditions

- areas underlaid by stratified drift aquifers which are being used for public water supply or have a strong potential for such use in the near future
- areas within 500 feet of water supply wells
- flood hazard areas as defined by the Federal Emergency Management Act
- lakes or ponds
- significant wetlands covered by Chapter 131, Section 40 of the Massachusetts General Laws
- watersheds for existing or potential water supplies
- prime agricultural land as designated by U.S.D.A. Soil Conservation Service
- areas zoned residential and subject to residential use
- areas of critical environmental concern

- historic districts
- natural areas protected by state or federal regulations
- state forests and fish and wildlife management areas
- land subject to article 97 of Amendments to Massachusetts Constitution
- state parks

For the purpose of engineered land disposal facilities and waste storage lagoons, the site must not include:

- areas underlaid by permeable bedrock without a sufficient cover of low permeability material or
- areas with slopes of over 15%

B. Additional Criteria

FOR ALL SITES:

- flooding potential
- impact on designated protection areas (conservation lands, critical habitat, wildlife, scenic rivers, recreation land)
- potential population exposure to toxic concentrations in the event of uncontrolled releases to air
- devaluation of property or business value

- proximity to residential property or sensitive sites such as schools, or dangerous sites such as airports

- transportation related risks

- consistency with local, regional and state land use and economic development plans

FOR LANDFILLS ONLY:

- unsaturated zone flow period

- saturated zone flow rate

- discharge from saturated zone to wells, springs or fresh surface water

- potential contamination of any aquifer which has high ground water quality or is a potential supply of potable water or has a contact with a water supply aquifer

- potential drainage into public water supply watersheds

FOR SITES WHERE WATER DISCHARGE IS PROPOSED:

- potential population exposure to toxic concentrations in water in event of exceedence of NPDES permit limitations

Appendix E
Government Offices and Contacts Responsible for Waste Management in Massachusetts

- U.S. Environmental Protection Agency, Region I, Air and Hazardous Division, Room 1903, John F. Kennedy Federal Building, Boston MA 02203 -- Implements the provisions of the Resource Conservation and Recovery Act. Coordinates regional hazardous waste activities.

Ira Leighton	223-5775

- Executive Office of Environmental Affairs (EOEA), 100 Cambridge Street, Boston, MA 02202, 20th Floor -- Responsible for overall policy and coordination of hazardous waste management activities.

Michael O'Hare Assistant Secretary	727-9800

- Department of Environmental Management, Bureau of Solid Waste, 100 Cambridge Street, Boston, MA 02202 -- Responsible for implementation of the Siting Act.

Debra Sanderson Coordinator, Hazardous Waste	727-4293

- Department of Environmental Quality Engineering, Division of Hazardous Waste, 600 Washington Street, Boston, MA 02111 -- Responsible for implementation of Hazardous Waste Management Act.

Bill Cass Director	727-0774

Appendix F: Bibliography

Arthur D. Little, Inc., "A Plan for Development of Hazardous Waste Management Facilities in the New England Region, Volumes I and II," prepared for the New England Regional Commission, September 1979. An overall evaluation and analysis of hazardous waste facility development in New England. Presents a regionwide hazardous waste inventory organized by management option and a process for selecting regional facility sites. Identifies and examines facility types, public and private sector responsibilities, financing alternatives, and long-term care and liability issues. Two volumes: Text(40 pages) and Appendices (200 pages). Available from the New England Regional Commission, 141 Milk Street, Boston, MA 02102.

Center for Science in the Public Interest, "Household Pollutants Guide," 1978. Identifies hazardous substances in popular use in homes. Suggests precautions and safe substitutes. 309 pages. Available from Anchor Books, Garden City, New York and the State Library, State House, Boston, MA 02133

Clark-McGlennon Associates, Inc., "Criteria for Evaluating Sites for Hazardous Waste Management," November 1980. Handbook that describes the basic elements of siting a facility. Presents criteria for evaluating a site. Includes a short primer about soils, groundwater, and contamination. Written for citizens and officials with no scientific background. 49 pages. Available from the New England Regional Commission, 141 Milk Street, Boston, MA 02102.

Clark-McGlennon Associates, Inc., "A Decision Guide for Siting Acceptable Hazardous Waste Facilities in New England," November 1980. Handbook for all participants in the siting process. Identifies their responsibilities; raises issues which participants need to be concerned about; indicates sources of assistance and information. 86 pages. Available from New England Regional Commission, 141 Milk Street, Boston, MA 02109.

Clark-McGlennon Associates, Inc., "Developing Acceptable Hazardous Waste Facilities in New England," Final Report, November 1980. Presents recommendations for a facility development strategy for New England. Answers three integral policy questions: who should initiate site selection, should local decision-making be preempted by state authority, what types of compensation, incentives and state support are appropriate for local communities? 37 pages. Available from New England Regional Commission, 141 Milk Street, Boston, MA 02109.

Appendix F: Bibliography

Clark-McGlennon Associates, Inc., "An Introduction to Facilities for Hazardous Waste Management," November 1980. Handbook that explains how facilities are operated to assure safety. Describes the major facility types. Written for citizens with little or no scientific or engineering background. 57 pages. Available from the New England Regional Commission, 141 Milk Street, Boston, MA 02109.

Clark-McGlennon Associates, Inc., "Negotiating to Protect your Interests," November 1980. Handbook that introduces siting process participants to the principles and applications of negotiation, compensation and incentives. 47 pages. Available from the New England Regional Commission, 141 Milk Street, Boston, MA 02109.

Fennelly, Paul F. et al., "Surveying Massachusetts Hazardous Wastes," Environmental Science and Technology, August 1977, pp 762-766. Review article of Massachusetts Division of Water Pollution Control inventory of hazardous wastes and assessment of management alternatives (see GCA entry, below). Issue available in the periodicals section of the State Library, State House, Boston, MA 02133.

GCA Corporation, Inc., "The Generation and Disposal of Hazardous Waste in Massachusetts," prepared for the Division of Water Pollution Control. October 1976. Presents an inventory of wastes by waste type. Identifies industries and industrial processes which generate wastes. Discusses existing facilities and policy recommendations for improving management practices in the Commonwealth. 250 pages. Available from the Division of Hazardous Waste Management, 600 Washington Street, Boston, MA 02111.

Harvard University, John F. Kennedy School of Government, Department of City and Regional Planning, "Massachusetts Hazardous Waste Management: Building the Local Role," June 1980. Examines the capabilities of Massachusetts localities to aid the state in the site screening process. Makes long- and short-term recommendations on utilization of local resources, state education responsibilities, and local-state coordination. 126 pages. Available from the Department of City and Regional Planning, Harvard University, Cambridge, MA 02138.

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League of Women Voters, "A Hazardous Waste Primer," 1980. Discusses the sources and characteristics of hazardous wastes, the impacts of improper handling, and the recycling, treatment, and disposal options. Reviews relevant Federal programs and suggests activities for citizen involvement. 8 pages. Available from League of Women Voters of the United States, 1730 M Street,NW, Washington, DC 20036.

Massachusetts Legislature, Commonwealth of, Special Commission on Hazardous Waste, "Procedures and Guidelines for Siting Hazardous Waste Facilities in the Commonwealth," First Interim Report, June 25, 1980. Establishes criteria for licensing facilities. Separates the facility-enforcement function of the DEQE from the facility-development function of the DEM. Authorizes a siting process, including specific roles for the Site Safety Council and the Local Assessment Committees. 63 pages. Available from the Special Commission on Hazardous Waste, Room 212A, State House, Boston, MA 02133

Metropolitan Area Planning Council, Boston, Massachusetts, "Hazardous Materials in the MAPC Region: Locations, Movements, Regulations," January 1979. Describeds the transporation of hazardous substances on public ways. Reports on accidental incidences involving hazardous substance transportation for each neighborhood in the metrpolitan area, plus routes and locations of hazardous materials. Presents an overview of relevant federal, state and local authorities. 236 pages. Available from the Metrpolitan Area Planning Council, 44 School Street, Boston, MA 02108 and at the State Library, State House, Boston, MA 02133.

New York State Environmental Facilities Corporation, Hazardous Waste Disposal Advisory Committee, "Technical, Marketing, and Financial Findings for the New York State Hazardous Waste Management Program," March 1980. Presents a comprehensive program for future management of New York's non-nuclear, industrial wastes. Findings and recommendations describe available technology, the desirability of regional disposal sites, and the feasibility of generating revenue sufficient to amortize bonds. 300 pages. Available from the New York State Environmental Facilities Corporation, 50 Wolf Road, Albany, New York 12205.

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O'Hare, Michael, "Not on My Block You Don't -- Facility Siting and the Strategic Importance of Compensation," Public Policy, Vol. 25, No. 4, 1977. Discusses the value of compensation in siting socially beneficial projects, the importance of choosing the correct kind and amount of compensation, and the strengths of facility auctioning. 458 pages. Issue available in the reference section of the State Library, State House, Boston, Massachusetts 02133.

Pojasek, Robert B., Editor, "Toxic and Hazardous Waste Diposal - Volume Four - New and Promising Ultimate Disposal Options," Ann Arbor Science Publishers Inc., Ann Arbor, Michigan, 1980. A compilation of technical papers on advanced methods of treatment and disposal. 313 pages. Available through the interlibrary loan system from the Andover Public Library.

Stelluto, Janis and Michael O'Hare, "State Policy Options for Siting Hazardous Waste Facilities: Report to the Special Commission on Hazardous Waste Siting - Commonwealth of Massachusetts Legislature," Draft Report, April 1980. Presents a siting process model comprised of fifteen stages and discusses the responsibilities of the state in each stage. Available from the Special Commission on Hazardous Waste, Room 212A, State House, Boston, Massachusetts 02133.

TRC Environmental Consultants, Inc., "Analysis of Options for Massachusetts Small Generator Exclusion Levels." Briefing Document prepared under the Technical Assistance Program of the U.S. Environmental Protection Agency Region I. Analysis of impacts of three alternative definitions of "small generator." 48 pages. Available from the Division of Hazardous Waste, Massachusetts Department of Environmental Quality Engineering, 600 Washington Street, Boston, MA 02111.

U.S. Environmental Protection Agency, "Questions and Answers on Hazardous Waste Regulations," Office of Water and Waste Management, SW-853, 1980. Explains the agency's regulations for the implementation of RCRA in an extremely well organized question and answer format. 140 pages. Available from the U.S. Environmental Protection Agency Region I, Division of Air and Hazardous Materials, John F. Kennedy Federal Building, Boston, MA 02203.

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U.S. Environmental Protection Agency, "Siting of Hazardous Waste Management Facilities and Public Opposition," Office of Water and Waste Management, SW-809, prepared by Centaur Associates, Inc. with the assistance of Clark-McGlennon Associates, Inc., November 1979. Explains the factors that lead to public opposition of facility siting. Identifies actions for reducing or overcoming the opposition. 388 pages. Available from the U.S. Environmental Protection Agency, Region I, Division of Air and Hazardous Materials, John F. Kennedy Federal Building, Boston, MA 02203.

U.S. Environmental Protection Agency, "Waste Alert," E.P.A. Journal, February, 1979. Contains fifteen articles on disposal, treatment, siting, waste exchanges, contamination, state and federal policy. Includes "A New England Hazard," an article on cleaning up an abandoned site in Lowell, Massachusetts. 40 pages. Available from the U.S. Environmental Protection Agency, Office of Public Awareness (A-107), Washington, DC 20460.

U.S. House of Representatives, Committee on Interstate and Foreign Commerce, "Hazardous Waste Disposal," Committee Print 96-IFC 31, U.S. Goverment Printing Office, Washington, DC, September 1979. Committee transcripts on hearings for implementing national policy on hazardous waste management. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Urban Systems Research and Engineering, Inc., "A Handbook for the Private Sector in the Use of Compensation and Incentives in the Siting of Hazardous Waste Management Facilities." September 1980. Introduces concepts of and developers' approaches to mitigation, compensation and incentives as tools in the siting of hazardous waste management facilities. 88 pages. Available from the U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460. (Contract No. -- 68-01-5034).

Urban Systems Research and Engineering, Inc., "A Handbook for States in the Use of Compensation and Incentives in the Siting of Hazardous Waste Management Facilities," Draft, September 1980. Introduces the concepts of and possible state approaches to mitigation, compensation and incentives as tools in the siting of hazardous waste management facilities. 114 pages. Available from the U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460. (Contract No. 68-01-5034).

Appendix G: Index

(Page numbers are organized by chapter. Chapter numbers are underlined.)

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